

UDC 377+378+004.02/331.5

Volodymyr Kovtunets

PhD (Math.), Associate Professor,

Leading Researcher,

Institute of Higher Education of the National Academy of Educational Sciences of Ukraine, Kyiv, Ukraine,

ORCID ID 0000-0001-9077-4867

vkovtunets@ukr.net**Sergiy Londar**

Dr. of Science, Professor,

Director

Institute of Educational Analytics, Kyiv, Ukraine

ORCID ID 0000-0003-1838-288X

londar.sergiy@gmail.com**Serhii Melnyk**

PhD (in Economics), Associate Professor,

Senior Researcher

Institute of Educational Analytics, Kyiv, Ukraine

ORCID ID 0000-0002-5724-2428

smelnykukr@gmail.com**Oles Kovtunets**

Senior lecturer

National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine

ORCID ID 0000-0002-0209-5715

olesoles@ukr.net

DIGITAL TOOLS FOR MATCHING QUALIFICATIONS TO THE LEVELS OF THE NATIONAL QUALIFICATIONS FRAMEWORK

Abstract. Mutual compatibility of different national qualifications frameworks (NQFs) based on their compatibility with the European Qualifications Framework (or another international one) is crucially important for the effective recognition of qualifications between states. In turn, it depends on the quality of "filling" NQF levels with qualifications. Right comparing professional (occupational) qualifications with NQF level is a non-trivial problem for standard developers. The quality of any national system of qualifications depends on the comparability of qualifications with the level of the NQF so the comparison process should be strongly argued to secure the comparability. For qualification standard developers (especially for occupational standard developers) there were no strictly justified recommendations on how to compare qualification with the NQF level. Th. Saaty's Analytic Hierarchy Process (AHP) is developed to resolve the problem of evidence-based comparing educational or professional (occupational) qualifications with the level of the National Qualification Framework (NQF). Research results give standard developers software tools based on a strong mathematical background to determine NQF level for developed standards. It is shown that Th. Saaty's Analytic Hierarchy Process (AHP) is close to optimal for solving the problem of qualifications comparing and therefore looks like the best option for such methods. However, AHP demands non-trivial qualifications in mathematics and computing. The key problem resolved by this research is simplifying procedures to ensure effective access to the tool for qualification standard developers with minimal qualification in mathematics and computing. It is proven that each problem of qualification comparison with NQF level may be reduced to three options of decision. At the lower level of the decision-making process, there are 3-4 descriptors of qualification. Therefore, a user should be capable of forming at most four matrices of judgments and computing the main eigenvectors with some level of accuracy. The maximal dimension of matrices is four (for example it's true for the Ukrainian case). But for some national qualification frameworks that use only three descriptors maximal dimension of matrices equals three. Therefore, some simple approximation methods for eigenvector computing may be applied using only minimal means of Microsoft Excel or analogous applications. For the most general case of four NQF descriptors, Microsoft Excel macro is developed to secure achieving any level of accuracy. Corresponding API is developed by PHP programming language. Both Excel and API are accessible for users at the

website of the Institute of Educational Analytics in Kyiv. The novelty of the article is that for the first time in national and international practice, it proposes an alternative/supplementary algorithmic method for determining the level of certain full and/or partial professional qualifications by the National Qualifications Framework, thus creating prerequisites for further automation of the activities of professional standards developers.

Keywords: qualification; National Framework of Qualifications; European Framework of Qualifications; comparison of learning outcomes; Analytic Hierarchy Process (AHP); AHP Application Programming Interface.

1. INTRODUCTION

Formulation of the problem¹. Qualifications – educational and professional (occupational) as well – may be determined by corresponding standards or by study programs.

On the other side according to provisions of the National Qualifications Framework (NQF) regulation, each qualification should be matched to the corresponding level of NQF.

It is important to emphasize that the content of the NQF level is being determined not only by the formal description of the level approved by the Government but also by the content of educational and professional (occupational) qualifications matched to the level.

Case studies have shown that mistakes in matching qualifications to the right level complicate recognition of qualifications. For example, in Ukraine like other European countries such as Austria, and Switzerland, the occupational qualification of a nurse is matched to the 5th or even 6th level of NQF. But in Germany, this qualification belongs to the 4th level of NQF². The scope of labor functions in all cases is similar. Therefore such mismatches not only complicate recognition but also may influence on quality of personnel and misunderstanding in the evaluation of human capital.

This needs to compare learning outcomes anticipated by corresponding standard or study program with NQF level description in a way that ensures keeping strong correspondence of complexity of qualifications at the same level (let's name it as comparison problem).

Different approaches to the problem are based on expert reviews. However, no methods for strong justification were applied. This research suggests an evidence-based justification procedure based on decision-making theory.

Resolving the problem is important for quality insurance in national and European qualification systems.

Analysis of recent studies and publications. Some practical approaches to resolve the problem were developed by institutions responsible for a system of qualifications at national or regional levels.

The National Qualifications Agency in Ukraine adopted recommendations for professional standard developers on the determination of NQF level [1]. Recommendations introduce some formulas for NQA level determination with weight coefficients, which values should be determined by experts. Along with that recommendations don't anticipate any more or less strong method for determination of coefficients. Determination of the coefficients needs further research,

The recommendations mentioned above follow recommendations developed by G.Hanf under the technical support of the European Training Foundation (ETF) [2]. These recommendations are descriptive and not based on some research.

¹ Authors express gratitude to prof, Yu,Rashkevych (National Qualifications Agency), *Erich Gutmann* (*INBAS Senior Consultant*, Germany), Arjen Dej (European Training Foundation, Italy), who helped in discussions to state a problem and understand its importance for different countries.

² https://www.bwp-zeitschrift.de/en/bwp_127987.php

Comparison of qualifications and comparison of qualification frameworks is extremely important for ensuring the quality of qualifications. It's a key problem for national and regional qualification systems.

At the early stage of qualification frameworks for European Higher Education Area formation compatibility of national ones was considered as the tool for convergence of national higher education systems [3].

In [4] comparison of national qualification frameworks with different levels of qualifications is studied. A mathematical model using artificial intelligence techniques is developed. This approach may be also applied to the problem studied in the proposed research but it demands training in AI. AI approach looks more costly than AHP application.

A lot of approaches to developing a sectoral framework – a framework of digital competencies for education – stimulated research on the comparison of different products using a special methodology of comparison [5].

Comparison of a qualification with NQA level demands making a decision. Therefore, decision-making methods may be applied. Moreover, concerning the high importance of these decisions, the optimality of decisions should be guaranteed in some way.

T.Saaty's Analytic Hierarchy Process (AHP) for decision making is rather argued and its optimality is strongly approved by psychological and mathematical methods [6,7]. Concerning small dimensions of priority matrices (3 or 4) the method ensures close to optimal decision even if matrices are inconsistent.

There are many cases of successful application of AHP in related areas: education, personnel selection, assessment, etc.

AHP was applied to optimize the model of public and private school inspection in Abu Dhabi [8]. In particular, AHP secured optimal weights for school inspection standards.

In [9] AHP is applied to optimize the criterion for the selection of candidates for vacant job positions.

AHP in combination with linear programming technique is applied to optimize human resource allocation problems [10].

The purpose of the study. The study is aimed at developing an algorithmic method within the framework of the decision theory to enable a systematic comparison of professional qualifications with the NQF level. It is assumed that the method under development will be suitable for use by developers of qualification from various fields of education with minimal computer skills and is developed by adapting T. Saaty's hierarchy method, which is currently the only method for making these decisions with mathematically proven efficiency.

Considering the European integration process, Ukraine needs to ensure a rapid and effective transition of the national training system from a strictly regulated and theorized model to a model that is flexible, mobile, and oriented to the requirements of the labor market. One of the important aspects of this reform process is the creation of the national qualifications system and qualifications framework, the formation of a relevant qualification register, and the development of a wide range of professional standards. At the same time, as of September 01, 2023, only about 300 professional standards have been developed and put into practice in Ukraine, which does not exceed 10% of the total amount required. As a result, most types of economic activity in Ukraine and the training of the employees for them are regulated by outdated approaches and procedures. The process is hampered by the fact that while creating professional standards, their developers face methodological issues, in particular, related to the determination of appropriate levels of the National Qualifications Framework for professional qualifications. This paper proposes a new approach to solve this urgent problem, facilitate the creation of professional standards, and establish prerequisites for its automation based on the development of appropriate algorithmic mathematical models.

Purpose of research. The research is aimed at the development of a decision-making theory method to compare a qualification with the NQF level. The only method of decision-making with mathematically proven efficiency is the hierarchy method AHP by Th. Saaty. The method should be modified for application by developers of qualification standards with minimal skills in computing. So, development of applications acceptable for qualification developers from different fields of education and levels of qualification is another purpose of the research.

2. THEORETICAL BACKGROUND OF THE RESEARCH.

Th. Saaty Analytic Hierarchy Process (AHP) is based on deep analysis of human thinking. The method is focused on assisting experts to formulate better-argued decisions. It combines the decomposition of a problem as a series of less complicated questions to expert and synthesis of obtained responses to get a recommended decision.

Comparison of some set of options is a principal element of reasoning in this decision-making method. Let's consider a situation when there are l possible options for achieving some purpose and an expert in the corresponding field has to establish the extent of their preferability.

The expert is asked to compare options using the standard table of coefficients. This table determines the scale for comparison.

Table 1

Coefficients of priorities. Fundamental Scale [3, p.105].

Coefficient of preference	Description	Comments
1	Equal importance	Two options are equal concerning the purpose
2	Weak or slight	Intermediate level between equal and moderate levels
3	Moderate importance	Experience and judgment slightly favor one option over another
4	Moderate plus	Intermediate level between moderate and strong levels
5	Strong importance	Experience and judgment strongly favor one option over another
6	Strong plus	Intermediate level between strong and very strong levels
7	Very strong (obvious or demonstrated) importance	One option is favored very strongly over another. There are practical pieces of evidence of domination.
8	Very, very strong importance	Intermediate level between very strong and extreme levels
9	Extreme (absolute) importance	The evidence favoring one option over another is of the highest possible order of affirmation (without any objections)

When the expert determined the preference of option with integer coefficients, then inverse preferences should be equal as an inverse value: if A dominates B with coefficient p , then B dominates A with coefficient $1/p$.

In rather complicated cases if an expert can't compare options by integers fractional coefficients (1.1, 2.3, etc.) are allowed.

Finally, expert conclusions may be presented by the matrix of judgments

$$P = (1 \ \dots \ 1/p_{11} \ \dots \ p_{11} \ \dots \ 1) \quad (1)$$

Table 1 represents some scales for measuring preferences. Th. Saaty writes "Many people think that measurement needs a physical scale with a zero and unit to object or phenomena. That is not true. Surprisingly enough, we can also derive accurate and reliable relative scales

that do not have a zero or unit by using our understanding and judgments, which are, after all, the most fundamental determinants of why we want to measure something. In reality, we do it all the time and do it subconsciously without thinking about it" [6, p.21].

AHP therefore demands from experts only to compare options pairwise. This is a big advantage of the method which simplifies expert work and allows him/her to think locally. But the output will be obtained as a decision of a global problem.

Comparison is consistent (and therefore matrix (1) is called consistent) if option A domination at B equals p , and if option B domination at C equals q , that domination of option A at C equals pq . Consistency reflects the proportionality of the created scale.

Consistency implies simple equality for matrix (1)

$$AA^T = E$$

where A^T means transposed matrix and E is unit matrix.

Expert is allowed to review comparison and finally achieve consistency of the corresponding matrix if possible.

The main eigenvector of the matrix (1) represents the extent of option priorities.

In the case when matrix P is consistent the main eigenvalue equals l , number of options.

3. MAIN RESULTS

To solve the problem of comparison of qualification with NQF levels one has to compare options of different levels.

Let some qualification standard Q and descriptors of the National qualification framework (NQF) be given.

At the highest level of AHP, it is necessary to compare the importance of NQF descriptors for a given qualification.

The expert has to determine a list of NQF levels that potentially may be appropriate for a given qualification.

At the lower AHP level, an expert has to establish the importance of each selected NQF level for the qualification concerning each NQF descriptor.

The principal problem to be solved is to develop possibly the simplest version of the hierarchy analysis method and corresponding software application accessible for developers of qualifications who have minimal skills in mathematics and computing. The reason for the problem statement is that qualification developers may not be rather sophisticated in mathematics and computing but involving specialists in AHP is impossible.

3.1. Comparison of NQF descriptors.

Ukrainian NQF has four descriptors: knowledge, skills, communication, and responsibility and autonomy [11].

European qualifications framework (EQF) has three descriptors: knowledge, skills, responsibility and autonomy [12].

Most of the national qualifications framework of European countries use three descriptors like EQF, some use four [13].

Therefore, at the highest level AHP should be developed for four or three options.

Finally, the qualification developer obtains at this step matrix of comparisons 4×4 .

$$D = \begin{pmatrix} 1 & \frac{1}{d_{21}} & d_{21} & 1 & \frac{1}{d_{31}} & \frac{1}{d_{41}} & \frac{1}{d_{32}} & \frac{1}{d_{42}} & d_{31} & d_{32} & d_{41} & d_{42} & 1 & \frac{1}{d_{43}} & d_{43} & 1 \end{pmatrix}. \quad (2)$$

Independently from matrix D consistency principal positive eigenvector w_d

$$w_d = (w_{d1}, \dots, w_{dl}), w_{d1} > 0, l = 4,$$

$$Dw_d = \lambda_d w_d,$$

corresponding to maximal eigenvalue $\lambda_{max} = \lambda_d$ [3, p.119]

must be computed in normalized form:

$$w_{d1} + \dots + w_{dl} = 1.$$

This is a vector of descriptor priorities.

If some framework is based on three descriptors matrix 4x4 may be also applied. In this case needless descriptor should be marked as having minimal importance over others (=1/9).

3.2. Comparison of NQF levels with regard to each descriptor.

First of all, we have to consider what maximal number of options (levels of NQF) may appear for the qualification developer to make a decision. Let's consider a standard qualifications framework with eight levels.

The levels may be grouped into three main groups based on standard levels of formal education (see ISCED [14]):

- 1) primary education level – level one;
- 2) secondary education and postsecondary levels – levels two, three, and four;
- 3) tertiary education levels - levels six, seven, and eight.

The fifth level is specific because it may include post-secondary non-tertiary education and a short cycle of tertiary education.

Usually, professional qualification demands some academic (educational) qualification as a condition of access to awarding, and professional qualification is positioned on a higher level than required educational qualification.

In some sense levels of formal education serve as benchmarks for qualification framework levels (for example see [14,2]).

In some cases, new professional qualification is based on the former professional qualification of a lower level. Such cases are simpler because usually may be at most two options for possible NQF levels of new qualification.

Therefore, we may conclude that professional qualification developers have to select the right level for the qualification among of three options. Usually following sets of options would be pre-selected before decision-making: levels 1-3 (primary and secondary education), levels 6-8 (higher education), levels 2-4 (secondary and postsecondary education), levels 3-5 (secondary and post-secondary education) and levels 5-6 (post-secondary non-tertiary, short cycle or bachelor level of higher education). This conclusion is based on recommendations [2]: G.Hanf recommends starting the comparison process with the selection key hypothesis concerning the level and comparing learning outcomes with the selected level and two neighboring levels.

Methodologies that are currently used to compare qualifications with the NQF level recommend determining the level using weak (intuitive) arguments. The proposed methodology involves the use of intuitive reasoning only for pairwise comparisons of hypotheses on a given scale with regard only to selected descriptors. Therefore, the new approach reduces the error probability to values close to zero.

Following the arguments above we have to compare three NQF levels concerning each descriptor of NQF.

First of all, we have to compare three selected levels concerning knowledge and to get the matrix of comparisons

$$K = \left(1 \quad \frac{1}{k_{21}} \quad \frac{1}{k_{31}} \quad k_{21} \quad 1 \quad \frac{1}{k_{32}} \quad k_{31} \quad k_{32} \quad 1 \right). \quad (3)$$

Having matrix K one has to compute the corresponding principal eigenvector of this matrix in normalized form

$$\begin{aligned} w_k &= (w_{k1}, \dots, w_{kl}), l = 3, \\ K w_k &= \lambda_k w_k, \\ w_{d1} + \dots + w_{dl} &= 1. \end{aligned}$$

Analogously, matrices S, C, R which compare levels of skills, communication and responsibility and autonomy should be filled, and corresponding normalized eigenvectors

$$\begin{aligned} w_s &= (w_{s1}, \dots, w_{sl}), \\ S w_s &= \lambda_s w_s. \end{aligned}$$

$$\begin{aligned} w_c &= (w_{c1}, \dots, w_{cl}), \\ C w_c &= \lambda_c w_c. \end{aligned}$$

$$\begin{aligned} w_r &= (w_{r1}, \dots, w_{rl}), \\ R w_r &= \lambda_r w_r. \end{aligned}$$

should be computed.

Analogously these vectors are named as vector of knowledge priorities (w_k), skills priorities (w_s), communication priorities (c), responsibility and autonomy priorities (w_r).

Finally, we have to compute the global priorities of each hypothetical level(option) of NQF:

$$\begin{aligned} \text{priority of the first option} &= w_{d1} w_{s1} + w_{d2} w_{c1} + w_{d3} w_{c1} + w_{d4} w_{r1}, \\ \text{priority of the second option} &= w_{d1} w_{s2} + w_{d2} w_{c2} + w_{d3} w_{c2} + w_{d4} w_{r2} \\ \text{priority of the third option} &= w_{d1} w_{s3} + w_{d2} w_{c3} + w_{d3} w_{c3} + w_{d4}. \end{aligned}$$

The level with highest priority is a decision of the problem. The qualification should be matched just with this level.

Consistency of matrices ensures optimality of the priorities vector. However for small dimensions used here the decision is close to optimal even in case of lack of consistency [6, p.129].

3.3. Computation peculiarities.

As it was mentioned above one of this research purposes is to simplify computations in a way to make proposed technique available for developers with minimal skills in mathematics and computing.

Computation of matrices D, K, S, C, R eigenvectors isn't rather simple needs more skills in mathematics and computing. So, we suggest some approximation algorithms effective just in studied problem concerning small dimension of matrices. Proposed algorithms are based on specific structure of preference matrix (inversely symmetry).

First of all, let's remind that if matrix

$$P = (1 \quad \dots \quad 1/p_{l1} \quad \vdots \quad \vdots \quad p_{l1} \quad \dots \quad 1) = (a_{11} \quad \dots \quad a_{1l} \quad \vdots \quad \vdots \quad a_{l1} \quad \dots \quad a_{ll})$$

is consistent, then its element may be presented in form

$$a_{ij} = \frac{v_i}{v_j}, i, j = 1, \dots, l [3,4].$$

In this case matrix eigenvalue equals l , and vector

$$v = (v_1, \dots, v_{1l})$$

is the eigenvector. So, computation of priorities may be performed in three steps:

- 1) set $v_1 = 1$;
- 2) for $i = 2, \dots, l$ set $v_i = v_1 p_{i1}$;

3) normalize vector v by division each element by sum of all elements.

Unfortunately, consistency is rarely achieved in reality. So approximate methods may be applied.

For positive matrices of judgments (1) having dimension less than 3:

$$A = (a_{11} \ a_{12} \ a_{13} \ a_{21} \ a_{22} \ a_{23} \ a_{31} \ a_{32} \ a_{33})$$

elements of principal eigenvector

$$W = (W_1, W_2, W_3)$$

may be approximated by formulas

$$W_I = (\sqrt[3]{a_{i1}a_{i2}a_{i3}}), I = 1,2,3. [4]$$

Therefore, this method may be easily applied for matrices K, S, C, R and also for matrix D in case of comparison with EQF or national frameworks with three descriptors.

Nevertheless, numerical experiments showed that accuracy of suggested method is rather good if Visual Basic for Excel Application is used and doesn't ensure good accuracy if some Internet programming tools (PHP) are applied.

To compare a qualification with NQF (Ukraine) there is a necessity to compute an eigenfunction of matrix D having dimension 4.

In this case following iterative algorithm may be applied to matrix P .

One has compute degrees of matrix: $P, P^2, \dots, P^n, \dots$, normalizing it at each step:

$$1) \ B_1 = P, B_2 = B_1 P;$$

$$2) \ P_2 = B_2 / \text{sum}(B_2), \text{ where } \text{sum}(B_2) \text{ is sum of all element of matrix } B_2, ;$$

....

n^{th} $B_n = B_{n-1} P, P_n = B_n / \text{sum}(B_n), \text{ where } \text{sum}(B_n) \text{ is sum of all element of matrix } B_n, ;$

... .

Computation process stops if absolute value of difference between matrices $P_n - P_{n-1}$ become less than pre-established precision $\varepsilon > 0$.

The desired eigenvector W element W_i equals sums of i -th row of P_n divided by sum of all P_n elements.

Independently of ε this is sufficient approximation of priorities vector.

This method is applicable to all matrices of judgments.

Finally, the result may be verified by equality of fraction obtained by dividing pairwise elements of vectors PW and W . These fractions should be approximately equal and equal to desirable eigenvalue λ . This of the evidence of the equality

$$PW = \lambda W.$$

3.4. Excel book for solving AHP problems for qualifications.

Excel-book Qualif-to-NQF,xlsm consists of the sheet D (Data&Results) with VBA macro IT. Macro IT includes three functions:

- 1) M_InvSymmetric(Mat As Variant) As Boolean (verifies correctness of a matrix),
- 2) M_Consistency(Mat As Variant) As Boolean (verifies correctness of a matrix),
- 3) Prior(Mat As Variant) As Variant (computes eigenvector of a matrix).

Macro IT applies these functions to matrices of judgments and finally computes

A user inputs data at sheet Data&Results. Data includes:

- 1) Title and type (academic or professional) of qualification;
- 2) Suggested NQF levels;
- 3) Matrix D of descriptors priorities for given qualification;
- 4) Matrices K, S, C, R of levels priorities concerning descriptors: knowledge, skills, communication, responsibility and autonomy;

5) Precision of eigenvectors computation $\varepsilon > 0$.

When user pushes a button “RUN” following messages shall be displayed:

- 1) “Matrix Ok” or “Matrix wrong”;
- 2) Matrix is consistent/non-consistent’;
- 3) Priority vectors for each matrix;
- 4) Main result - vector of level priorities.

The system verifies if matrices (2) and (3) are inversely symmetric, i.e., if there no some technical mistakes. So, if some matrix signed with “Matrix wrong” a user must verify data input, otherwise the result may not be correct.

Working Input/Output sheet for testing sample is at the picture below.

Qualification:					Practical Psychologist (Social area)															
Type: academic vs. occupational					Occupational															
Hypothetical levels of NQF (input 3 sequential)					6			7			8									
Accuracy					0,01															
NQF Description priorities																				
	Knowledge	Skills	Communication	Responsibility and autonomy	Levels priorities (Knowledge)			Levels priorities (Skills)			Levels priorities (Communication)			Levels priorities (Responsibility and autonomy)						
Knowledge	1,00000	2,00000	4,00000	8,00000	6	7	8	6	7	8	6	7	8	6	7	8				
Skills	0,50000	1,00000	2,00000	4,00000	6	1,000	2,000	0,250	6	1,000	0,500	0,200	6	1,000	9,000	4,000				
Communication	0,25000	0,50000	1,00000	2,00000	7	0,500	1,000	0,167	7	2,000	1,000	8,000	7	0,111	1,000	0,143				
Responsibility and autonomy	0,12500	0,25000	0,50000	1,00000	8	4,000	6,000	1,000	8	5,000	0,125	1,000	8	0,250	7,000	1,000				
Priorities	0,533333	0,266667	0,133333	0,066667	0,1984	0,109	0,721	0,116	0,63	0,2137	0,825	0,063	0,301	0,072	0,301	0,721				
Matrix consistency	Matrix is consistent				Matrix isn't consistent				Matrix isn't consistent				Matrix isn't consistent				Matrix isn't consistent			
non-consistent	Matrix is consistent				Matrix isn't consistent				Matrix isn't consistent				Matrix isn't consistent				Matrix isn't consistent			
Correctness of the matrix	Matrix Ok				Matrix Ok				Matrix Ok				Matrix Ok				Matrix Ok			
Solution: Priority of options																				
					6	7	8													
					0,110	0,076	0,420													
1. Clear yellow ranges																				
2. Fill four tables																				
3. Push the button below																				
RUN																				

Pic. 1. Screen shot of Excel sheet.

Users have to have in mind some peculiarities of decimal computations. Original matrix of judgments uses ordinary fraction. A computer operates with decimal fractions. Therefore, direct division by numbers 3, 6, 7, 9 leads to some small differences between original elements of matrix and their decimal representations. These differences will result in a "Matrix wrong" error message. So comparison of matrix pairwise inverse elements should be performed with some accuracy, say the same accuracy ε may be applied.

The user can review result. If suggested priority level strongly dominates others the suggested decision may be recognized as rather argued. Otherwise, the user can review his/her decisions concerning matrices of priorities and repeat computations.

Excel book may be uploaded from the site <https://iea.gov.ua/wp-content/uploads/2023/05/qualif-to-nqf.zip>.

3.5. API for solving AHP problems for qualifications

Another application for decision making in comparison qualification with NQF level is developed as Internet application by PHP language. Algorithm is the same is in VBA-Excel application and interface as well. Application is accessible at site https://iea.gov.ua/s_script/.

Internet application uses same notations as VBA one and may be integrated with other applications.

3.6. Testing and verification.

The system was applied to compare professional standard “Practical Psychologist (social work)” with NQF level. The standard is approved but it does not consist of statement about level of NQF.

The standard demands tertiary education of applicants – at least of bachelor degree. Expert agreed that this qualification may be compared with 6th, 7th or 8th level.

The system suggested 7th level as most appropriate to the qualification.

Independent expert agreed that the solution is rather reasonable.

Analysis of priority tables has shown that with regard to knowledge 6th level is most preferable. But concerning skills and autonomy and responsibility higher levels are more preferable.

Corresponding recommendations with examples for Ukrainian users are presented in [15].

4. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The study focuses on the creation of an algorithmic method for the implementation of systematic decisions by qualification developers from different fields of education with minimal computer skills, to automate their work on the practical comparison of professional and educational qualifications with the levels defined by the NQF (National Qualifications Framework). Such a practical comparison can be realized by using the MS Excel application program, which is available to all PC users. A detailed description of the developed method in the MS Excel environment is provided, which will allow users to solve their practical problems.

The main idea underlying the algorithmic method is to reduce the user's practical work to a pairwise comparison; the method proposed in this paper is an appropriate adaptation of the hierarchical T. Saaty's method, which is currently the only one that confirms reliable mathematical efficiency in decision-making. The systematic use of this method can improve the quality of the national qualifications system and facilitate its alignment with the European Qualifications Framework.

The developed method has been successfully tested by comparing the Ukrainian professional standard "Practical Psychologist (Social Work)" with the level of the National Qualifications Framework. In the process of developing and practical testing of the algorithmic method, it was found that the only strict requirement for users-developers of the standards is the accurate preparation of reasonable matrices of arguments using the fundamental scale. Taking this into account, the users of the method may need a short training to master it and use it in practice when working with educational and qualification descriptors.

The authors [8,9,10] point to a fairly wide range of applications of T. Saaty's method by individual researchers for recruitment, human resource allocation, optimization of educational institutions, etc.

In this context, it may be beneficial to further develop and adapt our method for its simultaneous use by a group of users, since qualification standards are usually created by working groups. Such an application could also be used for recruitment or allocation of human resources, since such decisions are made by several managers at different levels of authority.

Another promising aspect is research on the involvement of artificial intelligence (AI) in the use of the method. AI can be used as a consultant for standard developers in the comparison process. In addition, after training, AI can provide the formation of a decision matrix and can also perform well in pairwise comparisons of options.

REFERENCES (TRANSLATED AND TRANSLITERATED)

- [1] National Qualifications Agency. Ukraine. (2021, Sept. 21). *Decision on Approval Methodical recommendations for determining the level of professional qualifications according to the National Qualifications Framework*. [Online]. Available: https://drive.google.com/file/d/16zwwcLVUx3TBIZxbTF75Heiy8vodSKIY/view?fbclid=IwAR3FfSH50s3MY6D7MO8bPpUZmsCfRY_IBqWW793dLReX1Walj6f84uxA8CU (in Ukrainian)
- [2] G. Hanf. *Methodological recommendations for comparing qualifications with the National Qualifications Framework of Ukraine: draft dated 05.03.2015* [Online]. Available: https://ipq.org.ua/upload/files/files/03_Novyny/ (in Ukrainian)
- [3] B.Karseth and T.D. Solbrekke, Qualifications Frameworks: the avenue towards the convergence of European higher education? *European Journal on Education*, v. 45, Issue 4, p. 529-623, 2010, doi:10.1111/j.1465-3435.2010.01449.x. (in English)
- [4] V. V. Osadchyi, V. S. Yermieiev, S. V. Sharov, K. P. Osadcha, and S. L. Koniukhov, Comparison of national qualifications frameworks by means of web-oriented intelligent information system”, *ITLT*, vol. 56, no. 6, pp. 121–136, Dec. 2016. (in Ukrainian)
- [5] J. Mattar, C.C.Santo and L.M. Cuque, Analysis and Comparison of International Digital Competence Frameworks for Education. *Educ. Sci.* 12(12), 932, p.1-24, 2022, doi:10.3390/educsci12120932. (in English)
- [6] Th. Saaty, *Mathematical principles of Decision Making*, RSW Publications, 2010. (in English)
- [7] Th. Saaty, *Decision Making with Dependence and Feedback: The Analytic Network Process*, RWS Publications, 1996. (in English)
- [8] Al Qubaisi, A., Badri, M., Mohaidat, J., Al Dhaheri, H., Yang, G., Al Rashedi, A. and K. Greer, An analytic hierarchy process for school quality and inspection: Model development and application, *International Journal of Educational Management*, Vol. 30 No. 3, 2016. pp. 437-459, doi:10.1108/IJEM-09-2014-0123. (in English)
- [9] F.A. Taylor, A.F. Ketcham, and D. Hoffman, Personnel evaluation with AHP, *Management Decision*, Vol. 36 No. 10, pp. 679-685, 1998. doi:10.1108/00251749810245336. (in English)
- [10] L. Saaty, K. Peniwati and J. S. Shang. "The analytic hierarchy process and human resource allocation: Half the story", *Mathematical and Computer Modelling*, vol. 46, 7–8, pp. 1041-1053, October 2007. (in English)
- [11] Cabinet of Ministries of Ukraine. (2011, November, 23). Res. 1341, *On approval of National Qualification Framework*. [Online]. Available: <https://www.kmu.gov.ua/npas/244824068>. (in Ukrainian)
- [12] Council of the European Union, (2017, May, 22), *Council recommendation of 22 May 2017 on the European Qualifications Framework for lifelong learning and repealing the recommendation of the European Parliament and of the Council of 23 April 2008 on the establishment of the European Qualifications Framework for lifelong learning*. [Online]. Available: [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32017H0615\(01\)](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32017H0615(01)). (in English)
- [13] National Qualifications Frameworks (NQFs), CEDEFOP, [cedefop.europa.eu](https://www.cedefop.europa.eu/en/projects/national-qualifications-framework-nqf). [Online]. Available: <https://www.cedefop.europa.eu/en/projects/national-qualifications-framework-nqf>.
- [14] International Standard Classification of Education ISCED 2011. [Online]. Available <https://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf>. (in English)
- [15] V. Kovtunets and S. Melnyk, "Methodology of comparison of professional qualifications with the National Framework of Qualifications", in Presented at International Scientific and Practical Conference "Education of Ukraine in the conditions of marital state: management, digitalization, European integration aspects". October 25, 2022, Kyiv, Ukraine, *Proc.*, p. 134-136. [Online]. Available: https://iea.gov.ua/wp-content/uploads/2022/12/book-of-abstracts_ssi-iea_2022.pdf. (in Ukrainian)

Text of the article was accepted by Editorial Team 30.05.2023

**ЦИФРОВІ ІНСТРУМЕНТИ ДЛЯ ЗІСТАВЛЕННЯ КВАЛІФІКАЦІЙ З РІВНЯМИ
НАЦІОНАЛЬНОЇ РАМКИ КВАЛІФІКАЦІЙ**

Володимир Ковтунець

кандидат фізико-математичних наук, доцент

провідний науковий співробітник, Інститут вищої освіти НАПН України, м.Київ, Україна,

ORCID ID 0000-0001-9077-4867

vkovtunets@ukr.net

Сергій Лондар

доктор економічних наук, професор
директор Інституту освітньої аналітики, м.Київ, Україна
ORCID ID 0000-0003-1838-288X
londar.sergiy@gmail.com

Сергій Мельник

кандидат економічних наук, доцент
старший науковий співробітник
Інституту освітньої аналітики, м.Київ, Україна
ORCID ID 0000-0002-5724-2428
smelnykukr@gmail.com

Олесь Ковтунець

старший викладач
НТУ«Київський політехнічний інститут імені Ігоря Сікорського», м.Київ, Україна
ORCID ID 0000-0002-0209-5715
olesoles@ukr.net

Анотація. Аналітичний ієрархічний процес Т. Сааті (АНР) застосовано для вирішення проблеми зіставлення освітніх або професійних кваліфікацій з рівнем Національної рамки кваліфікацій (NQF). Для розробників стандартів кваліфікацій (особливо для розробників професійних стандартів) немає суворо обґрунтованих рекомендацій щодо порівняння кваліфікацій з рівнем НРК. Якість будь-якої національної системи кваліфікацій залежить від порівняння кваліфікацій з рівнем НРК, тож цей процес має бути добре аргументованим. Тому слід застосовувати методи прийняття рішень. Показано, що Analytic Hierarchy Process (АНР) Т. Сааті є близьким до оптимального для вирішення задачі порівняння кваліфікацій і найкращим варіантом для таких методів. Однак АНР вимагає нетривіальних кваліфікацій з математики та обчислювальної техніки. Ключовою проблемою, яку вирішує це дослідження, є спрощення процедур для забезпечення ефективного доступу до інструменту для розробників кваліфікаційних стандартів з мінімальною кваліфікацією з математики та обчислювальної техніки. Доведено, що кожен задачу порівняння кваліфікацій з рівнем НРК можна звести до трьох варіантів вирішення. На нижчому рівні процесу прийняття рішень є 3-4 дескриптори кваліфікації. Отже, користувач повинен бути здатний формувати щонайбільше чотири матриці суджень і обчислювати основні власні вектори з деяким рівнем точності. Максимальна розмірність матриць – чотири (наприклад, це справедливо для українського випадку). Але для деяких національних рамок кваліфікацій, які використовують лише три дескриптори, максимальна розмірність матриць дорівнює трьом. Тому деякі прості методи апроксимації для обчислення власних векторів можуть бути застосовані лише з використанням мінімальних засобів Microsoft Excel або аналогічних програм. Для найзагальнішого випадку чотирьох дескрипторів NQF розроблено макрос Microsoft Excel, щоб забезпечити досягнення будь-якого рівня точності. Відповідний API розроблений мовою програмування PHP. І Excel, і API доступні для користувачів на сайті Інституту освітньої аналітики в Києві. Новизна статті полягає в тому, що в ній вперше в національній та міжнародній практиці запропоновано альтернативний/додатковий алгоритмічний метод визначення рівня окремих повних та/або часткових професійних кваліфікацій відповідно до Національної рамки кваліфікацій. Це створює передумови для подальшої автоматизації діяльності розробників професійних стандартів.

Ключові слова: кваліфікація; Національна рамка кваліфікацій; Європейська рамка кваліфікацій; зіставлення результатів навчання; аналітичний ієрархічний процес (АНР); АНР прикладний програмний інтерфейс.

