Employee competencies in line with Industry 4.0

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Abstrakt

This paper deals with determining the necessary competencies of employees in industrial enterprises by the requirements of Industry 4.0. The term Industrial Revolution 4.0 is very frequent and somewhat mysterious for most people, and its content is unknown. It can be said with great certainty that it is already affecting and will affect both production processes, radical changes in their structure, and the advent of groundbreaking technology and communication equipment, but it will undoubtedly affect labour relations. The growth of new forms and methods of work based on automation, and digitisation, also applied in new models of labour relations, is already slowly beginning to threaten jobs in some segments of the economy. There are increasing demands for specific qualifications and skills, particularly in information technology, emphasising digitising processes, data processing and creating communication networks linking objects and people.

Keywords: analytical hierarchy process, exact methods, competencies, evaluation, Industry 4.0

1. Introduction

The skills required by employers are changing as digital technologies transform work content. Digital technologies cannot replace those jobs that require "the simultaneous use of a wide range of skills and dealing with unforeseen scenarios". In this sense, available jobs increasingly require unique skills, literacy, and numeracy. Over the next decade, technological change is expected to cause a decline in the importance of physical tasks and increase cognitive and social studies, digital tools, autonomy and teamwork. Therefore, a greater demand for digital and noncognitive competencies is expected. The E.U. labour market requires more noncognitive and digital skills, particularly combining the two. Almost all occupations that have expanded in recent years, such as engineers or service and business managers, require various ICT use and noncognitive skills (used, for example, in dealing with customers and work teams). In contrast, on average, occupations that require low digital skills and weak social interaction and emotional skills at work have declined. Although digital technologies have also changed the quality of care managers' work, they have had only a minimal impact on the day-to-day work of professional carers. Although digital technologies have yet to penetrate the sector fully, the required digital skills of carers have increased. This also indicates the growing importance of acquiring basic digital skills within this group of workers. [11]

In the future, most jobs are expected to require intermediate levels of digital and noncognitive solid skills. As technology-driven production processes become more complex and interconnected, workers are increasingly likely to organise and coordinate these processes, often using digital tools. An OECD (2018) study argues that to cope with the unknowns and variables that best characterise the expected work environment of the future, jobs will require workers to be equipped with a variety of skills: cognitive and metacognitive skills (such as critical thinking, creative thinking, the ability to learn, and self-management); noncognitive skills (such as empathy and collaboration); and digital skills (such as the use of new digital devices). [8]

Faced with the challenge of digital innovation from different directions (research, technological development, competitiveness, training and retraining), the European Commission itself has recently decided to adopt a single action plan for digital learning with three priorities:

- Better use of digital technologies for education and learning,
- Developing digital skills and competencies due to the importance of digital transformation,
- Enhancing knowledge through improved data analytics and predictive analytics

2. Method

The Analytic Hierarchy Process (AHP) is designed to deal with complex situations requiring an effective decision. This method allows the decision-maker to divide a multicriteria problem into smaller parts to create a hierarchical model. Once the model is constructed, the decision-maker derives a square matrix of pairwise comparisons for each parent element at each level. The elements of the matrix will represent the preferences of the decision-maker. The whole process of applying the AHP ends by performing a final synthesis to derive the resulting preferences of the alternatives to the goal. [1, 2, 10]

The method has the advantage of adapting to clearly defined data, such as price, speed of delivery, as well as personal experience and, last but not least, intuition. AHP allows to numerically determine the weight of each criterion instead of subjectively choosing the importance of the requirements, as in other decision-making methods. In the first stage, before applying the way, the evaluator must define all the criteria and sub-criteria based on which the specific evaluation will be carried out. The choice of measures and sub-criteria is made based on the knowledge and experience of each evaluator. If it is an initial evaluation of a specific evaluator, the subject must define the criteria according to their intuition or the model of another evaluator. [6]

Although it is one of the most objective and exact methods of multicriteria decision-making, it has advantages and disadvantages.

Among its most significant advantages are:

- Adaptation to clearly defined data such as price, speed of delivery, as well as personal experience and, last but not least, intuition. AHP allows the weighting of individual criteria to be determined numerically instead of subjectively choosing the weighting of criteria as in other decision-making methods. In the first stage, before the actual application of the process, the evaluator has to define all the requirements and sub-criteria based on which the specific evaluation will be carried out. The choice of criteria and sub-criteria are made based on the knowledge and experience of each evaluator. If it is an initial evaluation of a specific evaluator, the subject must define the criteria according to their intuition or the model of another evaluator. [7]
- The use of paired verbal ratings allows for more straightforward judgment.
- AHP requires that more comparisons be made than are necessary to determine the weights; this specification allows consistency to be verified by the judgement of the decision-maker; only n-1 comparisons are needed to compare the importance of n attributes (only two comparisons are necessary to compare characteristics A, B and C, A with B and A with C). In contrast, the AHP method requires n(n - 1)/2 comparisons (for A, B and C); it requires three comparisons: A with

B, A with C and B with C); clarity is ensured by formally structuring the problem - this will probably become a feature of all analytical methods.
- Exact determination of criteria weights and the possibility of quantitative evaluation of decision quality. [9,10]

Its disadvantages include [9]:
- If the verbal rating is used, then the rating scale is created by the rating subject, one criterion may be considered less important than the other, but the AHP method proves the opposite.
- Creating a custom rating scale for assigning weights to one entity may not be acceptable to other rating entities.
- The creation of the tree structure is burdened with a certain degree of subjectivity.
- Trying to retrofit the matrix R implies a distortion of the objectivity of the evaluation; adding a new alternative to the decision problem may lead to a change in the position of the original options.
- If we compare a more significant number of criteria, the comparisons, in this case, can be time-consuming.
- Limiting the method's validity to only consistent assessments, with practical assessments often being inconsistent.

The AHP method can be divided into four steps:

Step 1: Create the AHP hierarchy:

Problem-solving using multicriteria decision-making methods are structured into a hierarchy. That is, we divide the main problem into smaller discrete parts. The AHP hierarchy has three levels: objective, criteria, and alternatives. At the top of the hierarchy is the goal, in the middle are the standards on which we make decisions, and at the bottom are the alternatives we want to decide [8].

Step 2: Create a matrix of pairwise comparisons:

The second step is assigning scores to each pairwise comparison based on its significance level. These scores express how strongly each hierarchy element influences the above level [8]. The degree of significance score is created based on "expert estimation". In the AHP, the assigned values are selected from a classical 9-point scale [10], which can be extended with additional intermediate points if the significance of the compared elements is between two points on the scale.

Step 3: Calculate the weights:

One of the primary tasks in solving multicriteria problems is correctly and responsibly determining the consequences of the individual sub-criteria. For the above reason, it is necessary to know the problem to be solved and the meaning and impact of the criteria used to evaluate the outcome.[3]

Step 4: Consistency test:

Each P.P. matrix must satisfy the consistency condition in the AHP. We know two parameters within the consistency test: consistency index (CI) and consistency ratio (C.R.). We determine their
as follows

$$CI = \frac{\lambda_{max} - n}{n-1},$$

$$CR = \frac{CI}{RI},$$

Where R.I. is a random index that takes different values for the other criteria or alternatives of the matrix being compared, if the C.R. is less than 0.1, then the comparison result is acceptable, and matrix A is considered consistent. Otherwise, it is necessary to return to step 2 and rebuild the pairwise comparison matrix with an unsatisfactory C.R. [1,2]

In determining the necessary competencies of employees following the requirements of Industry 4.0 by applying the AHP method, we used the results of surveys and analyses that were carried out to determine the necessary competencies of employees following the requirements of Industry 4.0:

1. Research carried out within the VEGA project No. 2/0077/19 ***Work competencies in the context of the development of Industry 4.0*** - the output of the project published: PORUBČINOVÁ, Martina - FERO, Martin - FIDLEROVÁ, Helena - NOVOTNÁ, Ivana. Industry 4.0 in the human capital optics - empirical findings of work 4.0 competencies development within the Slovak automotive sector. In Prognostické práce. Vol. 13, no. 2 (2021), pp. 44-67. ISSN 1338-3590. [5]
2. Study prepared by the Republican Union of Employers - ***Analytical and Forecasting Basis for the Expected Development of Employment to 2030+,*** Strategy Paper WORK 4.0. [8]

Based on the above survey results, we have developed a list of required competencies of employees in industrial enterprises following the requirements of Industry 4.0:

Required competencies (K1 to K12):

- K1 - Programming skills;
- K2 - special knowledge of information technology;
- K3 - I.T. knowledge and skills;
- K4 - ability to interact with modern devices;
- K5 - exceptional understanding of production activities and processes;
- K6 - interdisciplinarity;
- K7 - information on I.T. security and data protection;
- K8 - data and information processing and analysis;
- K9 - understanding of legal issues;
- K10 - understanding of organisational and process issues;
- K11 - knowledge management;
- K12 - knowledge of ergonomics.

The alternatives were the need to have the competencies:

- The employee "must-have" the competence.
- The employee "should have" the competencies.
- The employee 'may have the competence.

The prerequisite for the application of the method is the creation of a hierarchical structure of the problem, which consists of the following elements:
Defining the goal of decision-making:
The decision-making objective has been defined as the "selection of employee competencies in line with Industry 4.0 requirements", following the requirements. This objective is linked to the problem related to the appropriate competencies of employees in industrial companies following Industry 4.0, i.e. the selection of quality employees.

Identification of solution options:
Solution options represent alternatives for employees to have each competency.

Determine criteria for evaluating solution options:
The required competencies defined the requirements at the "must-have", "should have", and "may have" levels. The criteria for each alternative were evaluated based on the surveys and analyses described above.
Creating a hierarchical structure:
The previous activities resulted in creating a hierarchical structure, Figure 1.

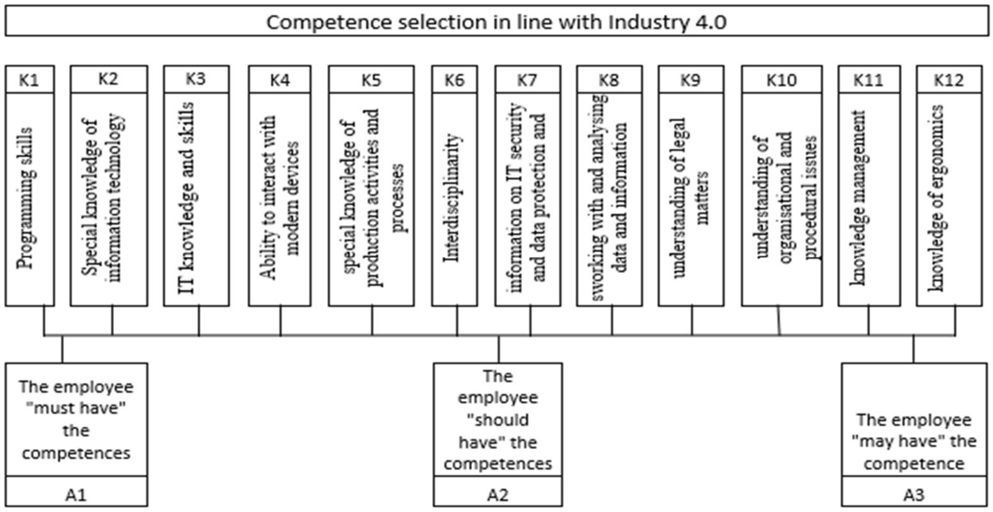

Figure 1. Representation of the three-level hierarchy for the decision-making process

In Expert Choice, we entered all of the above elements of the hierarchy - the goal, the evaluation criteria, and each of the alternatives - after running it.
How to work with Expert Choice:

1. Determining and writing down the goal, criteria and options for solving the problem.
2. Assigning weights to each criterion through pairwise comparison of measures.
3. Evaluating the variants by pairwise comparison for each criterion.
4. Assessment of the current status of the competency set of the selected employees.

Assigning weights to each criterion

A pairwise comparison matrix was created based on the scores of each criterion. The requirements are compared based on a rating scale in the pairwise comparison matrix. Figure 2 shows the pairwise comparison of the requirements by the E.C. program, where the values were entered directly into the matrix, and the consistency value is also displayed.

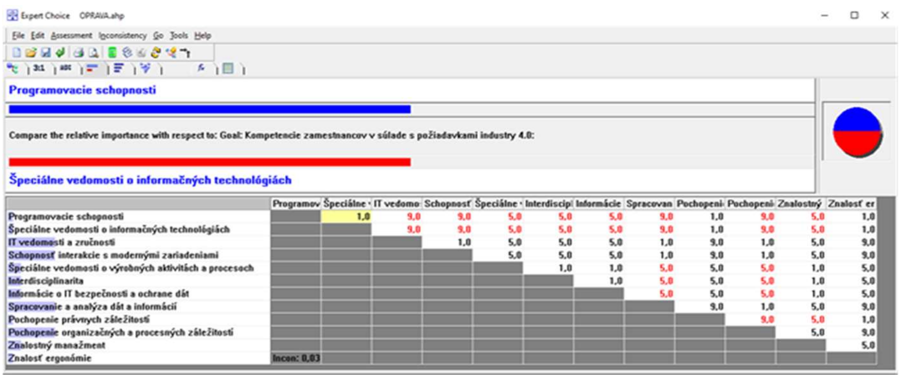

Figure 2. Pairwise comparison of criteria in Expert Choice

The program then calculated the weight of each criterion based on the pairwise comparison, which can be seen in Figure 3. The most important criteria are I.T. knowledge and skills, the ability to interact with modern devices, process and analyse data and information and understanding organisational and process issues. In addition to the importance rating of each criterion, Figure 3 also shows the value and analysis of consistency, which is supposed to be within 0.1. In our case, the character value is 0.03, so the logical consistency in the pairwise evaluation has been maintained. [3, 4]

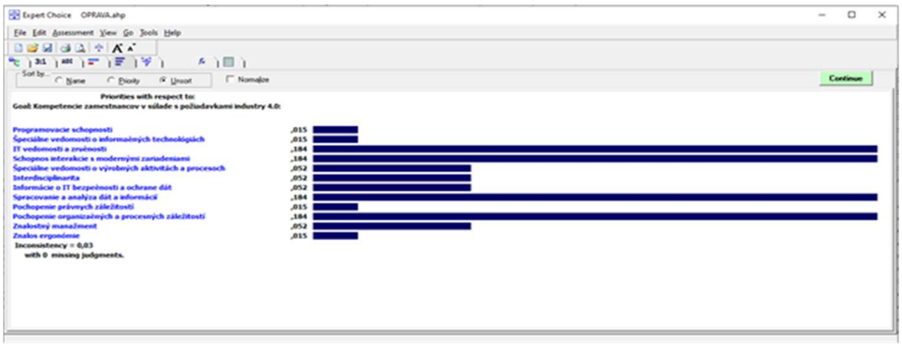

Figure 3. Criterion significance assessment and consistency analysis

Evaluation of variants according to individual criteria

The next step was to evaluate the alternatives according to the individual criteria, which are considered similar to the requirements. The result is a pairwise comparison of the other options according to standards K1 to K12. Figure 4 shows the pairwise comparison of variant K1 (programming skills). The figure also shows the calculation of the consistency value, which in this case is 0.05, which means that the consistency condition has been met. Consistency values were also completed in other pairwise comparisons of alternatives.

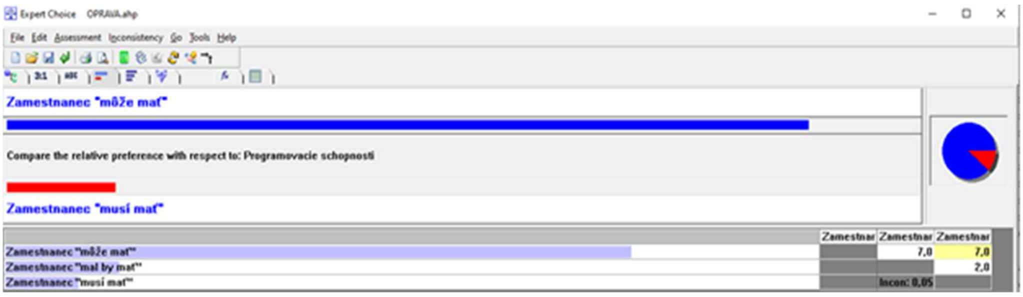

Figure 4. Pairwise comparison of variants according to K1

Figure 5 shows the ranking of the importance of the alternatives according to criterion K1 (programming ability) and then the scale based on the ascendancy values obtained by Expert Choice. The figure also shows the consistency, which in this case reached a value of 0.05, indicating that the pairwise comparison follows logical consistency. This is also the case for the other pairwise comparisons of alternatives, where the matter was 0.05 or 0.06.

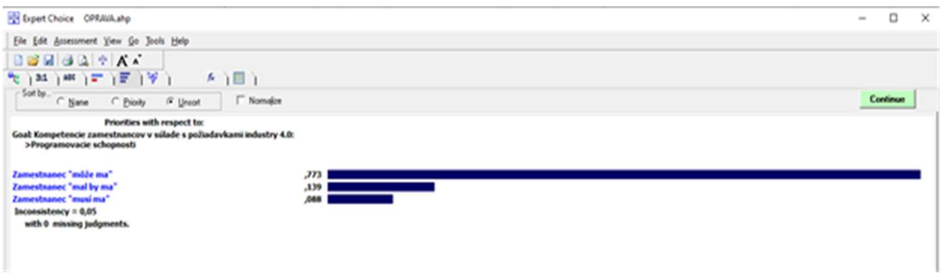

Figure 5. The significance value of alternatives according to K1

3. Results

As stated in the document "Action Plan for Smart Industry in the Slovak Republic", the fourth industrial revolution, also known as digital transformation, implies a complete change of perception in the labour market and education. With the automation and optimisation of processes, the demand for some occupations will decline, if not disappear altogether, while new disciplines will be created. The education system at all levels of education, including retraining and lifelong learning, needs to prepare its graduates to be able to successfully manage all aspects of work processes within the scope of their professional qualifications, including the application of the requirements for decent working conditions in the intelligent industry. Fixed job assignments and fixed working hours are becoming less and less critical. These developments offer new opportunities but also risks.

The labour market is changing and requires higher-level skills and increased digital literacy. It is essential to provide workers with opportunities for professional development and acquiring new skills. Employment requirements and ways of addressing the transformation of traditional/standard occupations to further labour market requirements are also necessary. The above must be a primary consideration in the relevant sectoral development policies, including support activities for human resource development. At the same time, the human resources development process in the context of the intelligent industry must consider the needs of all labour market participants, including disadvantaged people in the labour market, to support their access to training, in particular, to gain or retain employment. Measures must also be set towards increasing the share of employed graduates, increasing the percentage of employed graduates in the education sector and reducing the cost of retraining graduates by involving apprenticeships in education. [11]

To meet these strategic objectives, the following priority areas have been identified [11]:

- Research, development and innovation,
- Basic principles of I.T. security for the implementation of intelligent industry,
- Labour Market and Education,
- Reference Architecture, Standardisation and Technical Standards Development, European and National Legal Framework Conditions,
- Information and promotion.

Based on expert estimation, the AHP method has provided us with relevant results with which we can divide the competencies of employees in industrial enterprises following Industry 4.0 as follows:

Competencies that employees "must have" by the requirements of Industry 4.0:

- I.T. knowledge and skills;
- ability to interact with modern equipment;
- understanding of organisational and process issues;
- Data and information processing and analysis;

Competencies that employees "should have" in line with the requirements of Industry 4.0:

- information on I.T. security and data protection;
- interdisciplinarity;
- exceptional knowledge of production activities and processes;
- knowledge management;

Competences that employees "can have" in line with the requirements of Industry 4.0:

- exceptional knowledge of information technology;
- programming skills;
- knowledge of ergonomics;
- understanding of legal issues.

Figures 6 and 7 show the overall result of the multicriteria decision process, which describes the ranking of the options, in this case, the scale of the alternatives. The figure also shows the percentage of competencies that the employee 'must have', 'should have' and 'can have'.The ranking is based on the values that have been calculated by Expert Choice.

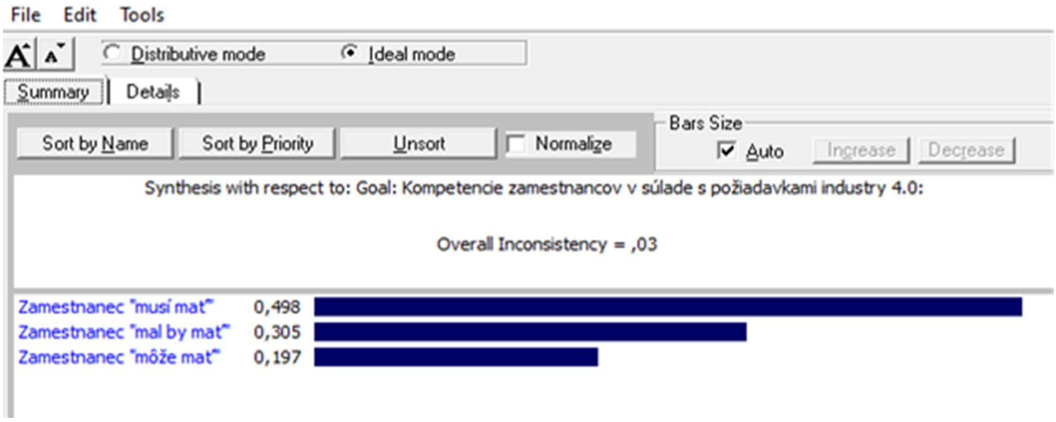

Figure 6. Resulting assessment of the significance of the alternatives

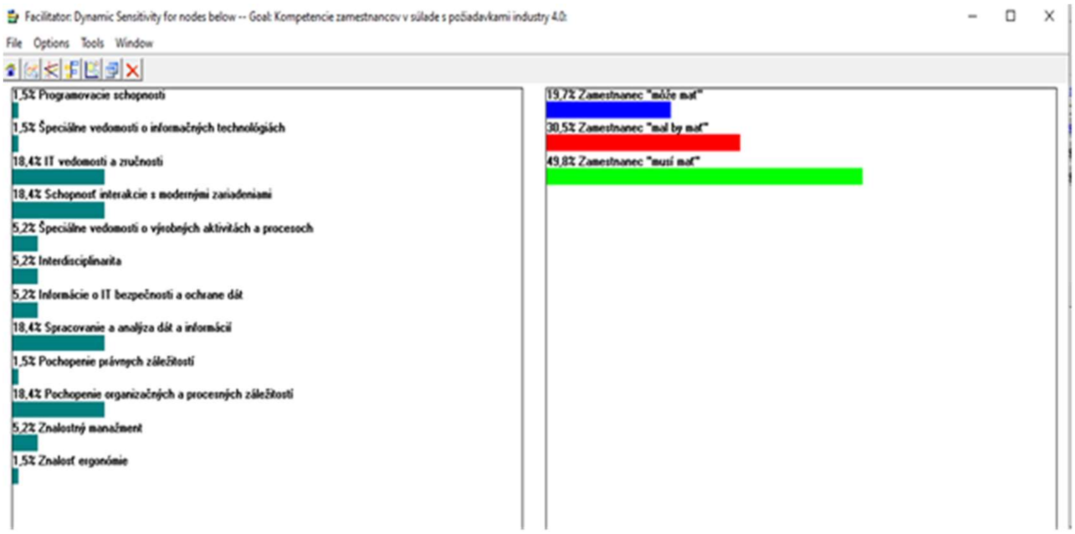

Figure 7. Resulting percentage ranking of criteria and alternatives

4. Discussion

A key objective for the next period in terms of preparing human resources for the labour market is to increase the level of competencies, upgrade qualifications, recognition of the results of non-formal and informal learning, flexible further adult education in the form of targeted retraining, upskilling and reskilling in line with innovative trends in the labour market. The lifelong learning system must move towards developing learning 'programmes' and, in particular, 'learning projects' that incorporate new tools and methodologies. These tools and methods must be capable of transferring technical knowledge leading to the acquisition of digital skills and the development of soft skills.

In addition to specific skills in their area of expertise, professionals must have many critical skills that will enable them to meet the challenges of the Fourth Industrial Revolution. [8]

Based on expert estimation, the AHP method has provided us with relevant results with which we can divide the competencies of employees in industrial enterprises following Industry 4.0 as follows:

5. Conclusion

The Fourth Industrial Revolution offers a new direction and unique opportunities for developing national economies. This significant societal change will significantly impact the labour market, resulting in the creation of employment. On the one hand, but with the inherent consequence, existing jobs will also be threatened. The threat to jobs does not necessarily mean their loss; more broadly, it also means their transformation into as yet unnamed positions. Various studies and expert opinions are currently appearing, estimating the percentage of jobs lost due to digitisation. The second group of ideas takes a more positive approach to the issue, arguing that modern technology will not take jobs away from people but will only change their nature and form.

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