

IMPROVEMENTS IN THE INDUSTRIAL ENGINEERING PROGRAM CONSIDERING THE OPINION OF THE GRADUATES.

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Summary -- Knowing the institutions where recent graduates come from is fundamental for both higher education institutions (HEIs) and companies. For HEIs it is necessary to know information about the performance of their graduates in the labor market in order to adjust and improve their academic programs, as well as to strengthen the reputation of the institution by demonstrating that its graduates meet the requirements demanded by the labor market, while for companies it allows them to identify HEIs that are training professionals with the skills and knowledge they require. Additionally, both HEIs and companies can contribute to the development the community, identify trends and plan strategies for talent development. Organizations evolve over time, which makes it imperative for HEIs to maintain the relevance and updating of their educational programs. In this context, there is a demand for graduates to possess skills that allow them to integrate and develop effectively in the workplace. This demand implies the need to make adjustments and modifications to the educational programs offered by HEIs.

This paper presents the results of a diagnostic instrument used to identify the skills required of graduates of the Industrial Engineering program of the Tecnológico Nacional de México in Celaya (TecNM in Celaya), which was applied to graduates who were working at the time of its application.

From the results obtained, areas of opportunity related to disciplinary knowledge and interpersonal skills, among others, were identified. In addition, a proposal of actions that can be implemented to remedy the findings is presented. The final objective of these actions is to obtain information to develop a strategic plan to improve the educational program.

Key words: updating, competencies, skills, graduates, continuous improvement.

Abstract -- Knowing the institutions from which recent graduates come is essential for both higher education institutions (HEIs) and companies. For HEIs, it is necessary to know information about the performance of their graduates in the labor market to adjust and improve their academic programs, as well as strengthen the reputation of the institution by demonstrating that their graduates meet the requirements demanded by the labor market, while It allows companies to identify HEIs that are training professionals with the skills and knowledge they require. Additionally, both HEIs and companies can contribute to community development, identify trends and plan strategies for talent development. Organizations evolve over time, which makes it imperative for HEIs to maintain the relevance and updating of their educational programs. In this context, graduates are required to possess skills that allow them to integrate and function effectively in the workplace.

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INTRODUCTION

In order to face the challenges imposed by technological, social, cultural and economic changes, HEIs have carried out important transformations related to academic, administrative and curricular activities [1]. According to Peña [2] the impact of speed of environmental changes on the professional training of future engineers. In this context, HEIs require close academic monitoring of their graduates to determine whether they the competencies required in the work environment in order to make the necessary adjustments in the contents and areas of knowledge considered in the curriculum.

Industrial engineers are essential for the efficient operation of companies and play a crucial role in the continuous improvement of productivity and competitiveness in a wide range of industries. According to Benítez [3] an industrial engineer is a professional who is dedicated to the planning, management and optimization of industrial process systems; he or she also analyzes production systems to find areas of opportunity and improve product quality.

In other words, their job is to analyze production problems and manage systems to optimize personnel, equipment, materials and processes.

The industrial engineer is a professional with knowledge in basic sciences and engineering, as well as with social and human sensitivity that enable him/her to design, plan, organize and manage various types of organizations. In addition to creating their own business opportunities, industrial engineers have the ability to promote, adapt and lead improvement processes in harmony with the rapidly changing environment, always seeking the optimal use of resources [4].

This type of engineer has different objectives that are indispensable, objectives such as making procedures or methods easier and easier to carry out, making a work plan to eliminate unnecessary movements in the manufacturing process, eliminating overproduction and, on the other hand, optimizing inventory, transportation and human utilization.

Taking all this into , the industrial engineer comes to play managerial roles within organizations. According to González and Granillo [5], from a multidisciplinary perspective, industrial engineers perform various functions and tasks in the company. There are a number of advantages or points in favor of an industrial engineer compared to professionals in other branches of engineering, which are mentioned below: versatile professional, indispensable in industries, problem solver, process optimizer, good remuneration, expert in teamwork, competitiveness and innovation, own entrepreneurship, entrepreneurial culture and opportunities. With these points in favor, the industrial engineer is a very complete professional [6].

Today, this professional profile is highly demanded within organizations because it helps to solve major engineering problems by providing feasible solutions to the organization; decision making is another task performed by the engineer, who must be able to choose the most appropriate decisions while taking into account the potential benefits for organizations. In order to make the right decisions, it is essential for the industrial engineer to have intellectual and personal skills, as well as a service attitude. Indeed [7] believes that the skills of an industrial engineer and his or her field of work are fundamental to our society, although they sometimes go unnoticed. An industrial engineer possesses the knowledge and skills necessary to perform in both a manufacturing plant and an insurance company, which is evidence of the distinctive qualities of these professionals.

The performance of industrial engineers in various professional fields requires competencies acquired during their academic training and those specific to the work area in which they work [8]. The following are some of the most important qualities needed to develop professionally as an industrial engineer: teamwork, analytical thinking, leadership, creativity, assertive communication and decision-making skills.

For Vargas [9], skills related to emotional understanding, creativity, interpersonal relationships and even artistic skills are also of utmost importance.

On the other hand, engineers require extensive knowledge related to basic sciences such as mathematics, physics or chemistry.

In this context, mathematics is particularly important in the training of industrial engineers, since it allows them to solve problems, explain phenomena and make predictions, validate proposals and develop comparison criteria that facilitate decision making [10].

For this reason, engineers are usually professionals who have developed analytical thinking, allows them to the necessary skills to perform various types of mathematical calculations to be applied in the workplace [7].

According to Rodríguez, Lara and Galindo [11], case studies through cooperative learning contribute significantly to the training of industrial engineers, since they allow them to propose solutions to real work situations, strengthening their decision-making capacity. Industrial engineering is an integrative discipline that focuses on the commercial and business environment, and interconnects with various areas and entities. An industrial engineer can specialize in areas such as mechanics, electronics and automation, industrial organization, industrial technologies, logistics and supply chain, and quality management, among the most common.

The presence of industrial engineers in the labor market is growing every day, as this profession offers development opportunities in various sectors such as administration, management and finance, manufacturing, operations, consulting, transportation, health and governmental entities, among others.

Although industrial engineers can work in many fields, they tend to work mainly in areas related to manufacturing, transportation and healthcare. The labor field is a key factor for the engineer's development, as it is the place where the knowledge and soft skills acquired throughout their university career can be put to use.

Although the labor field may be wide or narrow for some professions, for the industrial engineer, compared to other professions, it is very broad and continues to grow both in Mexico and the rest of the world.

According to Data Mexico [12], website of the government's Secretariat of Economy, in the fourth quarter of 2022 the distribution of industrial engineers in different industries and economic sectors was as follows (Figure 1).

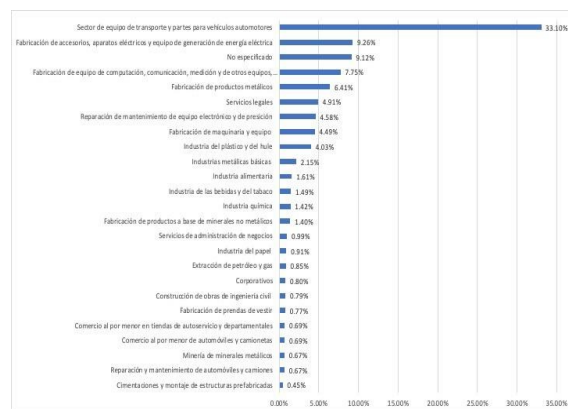


Figure 1. Distribution of industrial engineers by industry.
Source: Data Mexico.

From the information presented in Figure 1, it is concluded that a large number of industrial engineering professionals are working in the manufacture of transportation equipment and parts for motor vehicles, this is due to the large supply of companies in the industrial sector in our country.

However, many professionals tend not to practice their profession and dedicate themselves to other activities, leaving aside the existing opportunities in their field of work. However, being entrepreneurs is due to the skills acquired during their professional training that allow them to develop their ventures in an optimal and professional manner.

DEVELOPMENT

Methodology

This research is quantitative and descriptive, because through the methodology of the research conducted, it is intended to obtain information about the requirements of the labor field in which industrial engineering graduates of the TecNM in Celaya perform.

The main objective of this work is to develop and apply an instrument for the detection of aspects related to the competencies and skills requested by the companies of the region to the graduates of the Industrial Engineering program through a questionnaire in *Google Forms*.

The following is a detailed description of each the activities carried out.

Design of the diagnostic instrument aimed at graduates.

For the design of the diagnostic instrument, it was essential to consider an analytical method as part of the research in order to validate the instrument through verifiable mechanisms such as statistics, among others. The variables used in the instrument were:

- Graduates practicing their profession
- Range of salary received

- Requirements to obtain a job
- Work areas in which graduates are employed

The diagnostic instrument includes different types of questions in order to gather the necessary information to perform a statistical analysis. The objective of this analysis is to propose strategies to remedy the areas of opportunity identified in the industrial engineering curriculum offered at TecNM in Celaya. The following are the types of questions included in the instrument:

- Multiple choice questions with a variety of answers to choose from.
- Ranking questions that provide qualitative feedback on the graduates to whom the diagnostic instrument was applied.
- Closed-ended questions that helped to determine the current status of the question being asked.
- Open-ended questions that have the advantage of providing the point of view of the graduate who answers the instrument.

The proposed diagnostic instrument makes it possible to segment the graduates into two groups. The first question differentiates between those who are working in the profession and those who, for some particular reason, not currently working.

Sample selection

In an investigation there is an element that is of vital importance for the development of the investigation, that is, determining the size of the population sample. A population sample is a set of elements that represent a population, that is, they constitute a fraction of the total number of individuals that will be considered. Within the methodology, the following formula (Eq. 1) was used to determine the population sample size corresponding to the industrial engineering students of the TecNM in Celaya who graduated in the year 2022, during the January-June and August-December semesters.

$$n = \frac{Z^2 \alpha N}{e^2 (N-1) 2 + Z^2 \alpha} \quad \text{Eq. (1)}$$

Where:

n= size of the population sample to be obtained
Z= value corresponding to the selected confidence level
 σ = standard deviation of the population
N = population size
e= represents the acceptable limit of sampling error.

Application of the diagnostic instrument directed at graduates

The diagnostic instrument was sent via e-mail to the population of graduates from the aforementioned period, which totaled 108 graduates, obtaining a total of 65 responses, which is the exact value of the sample size considered.

DISCUSSION AND ANALYSIS OF RESULTS

The statistical analysis of the information was performed using Excel software. The results for each of the variables considered are presented below:

Graduates practicing their profession

When analyzing the sample of students who answered the diagnostic instrument, it was found that at that time only 43% of those surveyed were working mainly in companies in the region, most of which belong to the automotive sector, performing a variety of activities, the most important being quality engineer, followed by process analyst and engineer, and business development leaders.

Counting the difference between the time taken by each graduate to find employment while pursuing his or her career, it was found that 67% of the graduates who responded to the instrument found work in less than three months; 7% of the graduates took between six months and a year to find employment; 7% were hired immediately and 13% took between three months and more than a year to be hired.

Range of salary received

With respect to salary, 60% of those surveyed receive a salary ranging between 5,000 and 15,000 pesos; while the other 40% receive salaries ranging between 15,000 and 25,000 pesos, taking into account that the main requirements requested from this segment of the population are practical knowledge, the use of computer tools and organization, as well as work methods. In order to advance to higher levels within a company, it is essential to have not only the technical knowledge acquired during the educational program, but also soft skills. These skills have become a prerequisite for promotion.

Requirements to obtain a job

The sector of graduates who took between 6 months and a year to find a job, consider that this situation is caused by the requirements requested by the companies or the difficulty in finding a job due to various situations. According to those surveyed, among the requirements to obtain employment are (Figure 2).

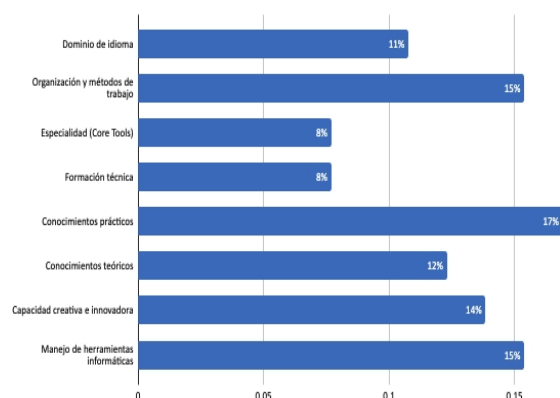


Figure 2. Skills required to obtain employment.
Source: Own elaboration.

Based on the figure presented, it is evident that companies value mainly practical competencies, skills in computer tools, and the ability to organize and improve work methods, in addition to creativity and innovation. Therefore, we conclude that it is essential to strengthen the collaboration and relationship with companies in the region to better understand the competencies they demand and, in this way, prepare future graduates effectively for their insertion into the labor market. This closer connection with the business environment can contribute significantly to improving the employability and success of graduates in the labor market.

Factors for not being hired

Based on the respondents' experience with the requirements requested in the recruitment processes, Figure 3 below shows the factors that, from their perspective, have been determining factors for not being hired:

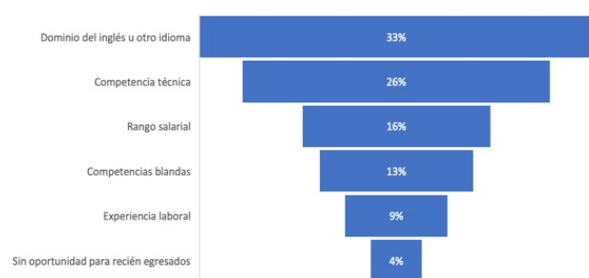


Figure 3. Factors for not being hired.
Source: Own elaboration.

From the data presented, it is clear that proficiency in a second language and technical competency are the main factors affecting the employability of graduates. This evidences the need to strengthen the teaching of languages and technical competencies in the educational program.

Language courses are often perceived as less relevant compared to other technical subjects, but this study highlights the critical importance of second language proficiency in today's work environment, where global communication is essential. It is recommended that measures be implemented to encourage interest in and appreciation of languages, as they are a required skill in an increasingly globalized and competitive society. Language training can significantly improve the employment opportunities and professional success of graduates.

Job performance

The reasons that, in their personal experience, graduates consider decisive at the time of receiving a promotion or being promoted in companies are presented below (Figure 4):

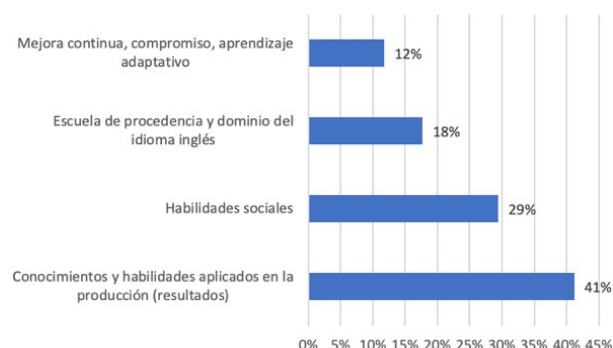


Figure 4. Important aspects to be promoted in the company.
Source: Own elaboration.

From the above results, it can be concluded that respondents consider knowledge and skills applied in the company as the determining factor in achieving a promotion, with 41% of the responses reflecting this view. In addition, 29% consider that social skills are also of great importance in this process. On the other hand, 18% mentioned the school of origin and the command of the English language as relevant factors for job promotion. Finally, 12% say that continuous improvement, commitment and adaptive learning are key elements for advancement in the company. These results underscore the diversity of factors that can influence career growth. However, the majority of respondents highlight the importance of technical and practical skills, as well as soft skills on the road to promotion.

Areas of the Industrial Engineering educational program susceptible to improvement

Figure 5 shows the results of the opinions of the graduates to the question of which of the following are considered to be

the areas of the Industrial Engineering educational program susceptible to improvement:

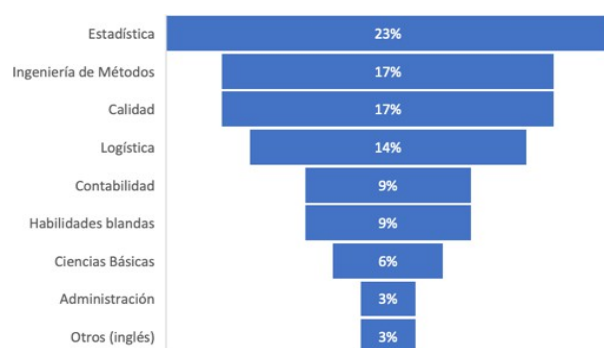


Figure 5. Areas of opportunity of the Industrial Engineering program.

Source: Own elaboration.

Based on the information provided by the graph, it can be concluded that there are specific areas that require special attention to improve the competencies of graduates. These areas include Statistics, which is the main one with 23% of mentions, followed by Methods and Quality Engineering with 17%, Logistics with 14%, as well as Accounting and Soft Skills, both with 9%. The above results highlight the importance of focusing on strengthening these areas in the educational program to ensure that graduates are better prepared to face the challenges of the labor market and contribute to the success of companies, it is necessary to dedicate additional resources and efforts to the training and development of skills in these disciplines.

Areas with job opportunities

Figure 6 shows the areas in which industrial engineers are most in demand and therefore where there are more job opportunities, from the perspective of the respondents:

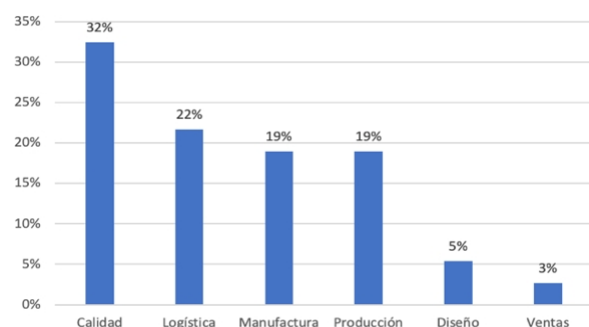


Figure 6. Areas with job opportunities for industrial engineers.

Source: Own elaboration.

According to the data provided by figure above, is concludes which area with greater than

The most important employment opportunities for graduates of the industrial engineering program are Quality (32%), followed by Logistics (22%) and Manufacturing and Production (19%).

The above information suggests a clear demand in the labor market for professionals with experience and skills in these areas. In this context, it is recommended that the educational program prioritize and reinforce the training of students in the areas of Quality, Logistics and Manufacturing.

This will allow graduates to be better prepared and aligned with the needs of the labor market, thus increasing their employment opportunities and contributing to the success of companies in these specific areas.

In order to obtain a better understanding of the technical competencies demanded by companies in the region for graduates, we have analyzed the responses collected through the diagnostic instrument. The areas of focus in this analysis include Statistics, Methods Engineering, Quality, Logistics and Accounting.

Sixty-five percent of the graduates said they felt sufficiently prepared to interact with graduates from other institutions when they entered the professional arena. However, 35% (a significant and worrying figure, representing more than a third of the graduates) expressed feeling insecure in this area. It is important to note that only three of the respondents who are currently working in the automotive sector, known for its high standards, responded negatively.

The analysis of the information gathered through the diagnostic instrument reveals key aspects to improve the graduation competencies in the Industrial Engineering program:

- Identification of areas of opportunity in the curriculum and areas of knowledge considered essential by graduates.
- Development of a strategic plan in the curriculum to address identified areas of improvement.

Consequently, it is essential to take measures to address these aspects and foster the development of the necessary competencies among future graduates, enabling them to perform successfully in the work environment.

Guzmán et. al [13] consider the follow-up study of graduates to be the means through which HEIs can obtain information about the competencies and skills required by future professionals so that their insertion into the labor market is quick and successful. The work of Zalapa, González and Silva [14] details the follow-up study applied to 11,444 graduates of various educational programs . The results made it possible to

collect relevant information to improve the professional profile among other aspects.

Both studies share the objective of using the results to generate recommendations that lead to improvements in educational programs, adjusting their content to align it more closely with expectations of the labor market. In our case, the data obtained will allow us to carry out a comprehensive evaluation of the of the program of Engineering Industrial Engineering program, identifying possible areas for improvement to ensure that graduates have the necessary competencies to compete in the local and regional professional environment. On the other hand, Carmona, González and Crespo [15] conducted a study on the labor market insertion of graduates in three different areas. The results show that the knowledge and skills learned in the opinion of the graduates are at the Very Adequate level and the perception of the teachers' training in the Theoretical Modules was Very Adequate. Similarly, our work, of a quantitative and descriptive nature, focuses on analyzing the adequacy of the Industrial Engineering program of the TecNM in Celaya from the perspective of the competencies and skills demanded by the regional labor market. As in the study described above, we seek to evaluate the relevance of the curriculum in terms of its preparation for the labor environment through the opinion of graduates.

CONCLUSIONS

Considering the competencies required for graduates is of vital importance for any educational program for several fundamental reasons: *Relevance to the labor market*: the competencies required by the labor market change over time due to technological advances, changes in industry and economic trends. An educational program that adapts to these demands ensures that its graduates are competitive for current and future employment opportunities.

Job placement: students invest significant time and resources in their education with the expectation that it will provide them with job opportunities. An educational program that incorporates the necessary competencies increases the likelihood that graduates will be hired.

Quality of education: The quality of education is measured in part by the ability of graduates to apply what they have learned in real-world situations. By teaching relevant competencies, an educational program can show its effectiveness in training students for professional life.

Teaching effectiveness: considering the competencies required by the labor market helps teachers to better focus and design curricula and teaching methods. This can lead to a

more effective teaching and better understanding of the content by the students.

Institution competitiveness: educational institutions that adapt to the changing needs of society and industry are more competitive and attractive to potential students, which can increase enrollment and enhance the institution's reputation.

In summary, considering the competencies required for graduates is essential for an educational program to be effective, relevant and capable of preparing its students for success in the world of work. It is also critical to the competitiveness and long-term impact of the educational institution.

The following are some proposals to promote the development of the graduation of future graduates of the industrial engineering program:

- One of the factors that should be emphasized looking for a job with a high salary range or to be able to be part of a promotion in the company where you work, are the communication skills, taking English as the main second language.
- Considering that institutionally only up to the fifth level of the English language is required of students, it is necessary to offer students specialized English in technical concepts to perform successfully in any company, which is what is mainly required in the industry.
- The subjects where the theoretical concepts are addressed and the practical part is implemented must have an updated approach to what is currently sought in the industry, proposing the development of new projects by continually changing the sector to which they belong in order to eliminate the possibility of projects being recycled from previous semesters.
- In addition, it is suggested that the most important subjects in the educational program be taught by professors with disciplinary training related to the specialty subjects offered, and that these subjects be taught with the appropriate academic rigor.
- The skills of expression and others related to *soft skills* could be reinforced in all subjects and especially in those that integrate the specialty modules, as well as in subjects where projects are carried out (Manufacturing Project) to name a few, where not only a project is developed, but also a "GEMBA" which is what is really seen and experienced in the industry. It is also imperative to reinforce the basic concepts and terms that are required in the industry and provide students with tools to become familiar with aspects about:

- Gemba, *Lean Manufacturing*, Six Sigma and other terms OTD (*on time delivery*), OTY (*on time yield*), 5's, Kaizen, Va/Ve, among others.
- Likewise, it is necessary to reinforce the use of methodologies required by the industry such as: 5S, Total Productive Maintenance (TPM), *One Piece Flow*, *Housekeeping*, Kanban, Task Automation, Poka Yoke and *Value Stream Mapping* (VSM), among others.
 - Regarding the use of computer tools, it would be desirable to implement the use of software in subjects such as Probability and Statistics, Inferential Statistics I, Inferential Statistics II and Statistical Control.

From the analysis conducted, it is crucial to carry out improvements in the teaching and learning processes within the industrial engineering program.

These improvements should focus on the inclusion of activities that address essential theoretical concepts for the workplace, the acquisition of a second language (preferably English), as well as the development of oral and written communication skills, interpersonal skills and the mastery of computer tools. These competencies are fundamental to contribute to the training of industrial engineering students in order to favor their insertion in the current and future labor market.

According to Vega-González [16], it is urgent for HEIs to carry out permanent planning in engineering education programs, considering that future professionals must have the competencies that will enable them to face economic and social changes.

According to Capote, Rizo and Bravo [17], HEIs must promote, through innovative teaching and learning processes, the training of students so that they become graduates with solid disciplinary knowledge, the ability to make decisions and face the social responsibilities of today's world. The adaptation and constant updating of educational programs are essential to meet the changing needs of industry and ensure that graduates have the necessary competencies to face the professional challenges caused by the evolution of the labor market and the demands of industry.

In this way, it will be possible to ensure that graduates of the industrial engineering program have the knowledge and skills that will enable them to contribute to the economic and social development of the country, to successfully face current and future professional challenges.

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