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GMM-BI: A methodological guide to improve organizacional maturity in Business Intelligence

GMM-BI: Una guía metodológica para mejorar la madurez organizacional en inteligencia de negocios

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ABSTRACT: Maturity models in Business Intelligence (BI) put forth a baseline for measuring the value of initiatives in this area, helping organizations to understand where they are and what improvements are needed. In this context, the main problem for organizations that are aware of their current level of BI maturity and want to implement improvements is to know how to make them. Currently, there are no studies guiding organizations to make BI maturity improvements. This paper presents a framework called GMM-BI to measure, analyze, plan, and implement BI maturity improvements in an organization for a given key process area (KPA). In general, the framework is instanced in KPA knowledge for which three procedures are defined so that organizations can perform the activities defined for a given KPA. In addition, the proposed guide considers a methodological path to implement improvements in the current maturity state of the KPA involved. This methodological path describes the different phases, activities, and tasks to be performed by an organization to implement these improvements. The result of applying this methodological guide is a qualitative description of the current BI maturity level of the organization and a quantitative characterization of the maturity improvement of the processes making up the KPA involved. In addition, this methodological guide is applied in three case studies.

RESUMEN: Los modelos de madurez en Inteligencia de Negocios (BI: Business Intelligence) enuncian una línea base para medir el valor de las iniciativas en ese ámbito, ayudando a las organizaciones a entender dónde están y qué deben mejorar. En este contexto, se presenta la problemática para las organizaciones que desean implementar mejoras, pero desconocen cómo realizarlas. Actualmente, en el estado del arte existe una carencia de estudios relacionados para guiar a las organizaciones a implementar mejoras en su madurez en BI. El presente artículo presenta un marco de trabajo que permite medir, analizar, planificar e implementar mejoras en la madurez en BI en una organización para un área de proceso clave KPA (Key Process Area) en particular. Sin pérdida de generalidad, el marco de trabajo se ilustra en la KPA conocimiento, para la cual se definen tres procedimientos para que las organizaciones puedan realizar las actividades definidas para dicha KPA. También la guía considera una ruta metodológica para implementar mejoras en el estado de madurez actual que presenta la KPA en cuestión. Esta ruta metodológica describe las distintas fases, actividades y tareas que debe realizar una organización para implementar dichas mejoras. El resultado de la aplicación de la guía metodológica es una descripción cualitativa del nivel actual de madurez en BI que presenta la organización, y una caracterización cuantitativa de la mejora en el grado de madurez de los procesos que conforman la KPA bajo consideración. Además, la guía metodológica se aplica en tres casos de estudios.

1. Introduction

BI is rapidly becoming a critical factor in the competitive strategy of today's organizations because it satisfies business needs aiming to respond to a competitive and globalized market, which has influenced rapid BI advance. This has been understood by many Chief Information Officers (CIOs) since, according to Gartner Group, BI led investment rankings in Information Technology (IT) between 2012 [1] and 2013 [2].

Organizations usually make a significant financial investment to implement BI initiatives and, therefore, they seek to maximize return on investment (ROI). In addition, organizations need to measure their current state in BI initiatives as compared to their competitors.

In [3] is suggested that maturity models establish a proper baseline for measuring the value of their BI initiatives,

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along with helping organizations to understand where they are and what improvements they need to make.

In this context, organizations, aware of their current BI maturity level and which want to improve this level, require learning how to make these improvements.

This guide for maturity improvement (GMM-BI) aims to implement improvements in the organizational maturity of BI activities for a specific business area.

This paper is organized as follows: the first part will show the reference model used as a basis for GMM-BI development. Secondly, the different stages of organizational maturity will be presented in detail for BI activities. Thirdly, the framework developed to improve BI maturity will be presented. Fourthly, how to determine the level of organizational maturity in BI will be shown. Fifthly, the procedures developed for performing the activities that includes the KPA knowledge will be shown. Finally, the application of GMM-BI is presented and conclusions are stated.

2. Reference model

In developing this proposed methodology, the capability maturity Model of Enterprise Intelligence (MEI) [4] was taken as a reference.

This model was selected through the comparative analysis of a set of six BI maturity candidate models: Enterprise Intelligence (EI), Enterprise Business Intelligence (EBI), HIERARCHY, Enterprise Business Intelligence 2 (EBI2), the Data Warehouse Institute (TDWI), and the Service Oriented Business Intelligence (SOBI). Table 1 summarizes the evaluation of the more relevant characteristics of BI maturity models in terms of the key process areas that they focus [5].

Table 1 Characterization of six BI maturity models in terms of KPA they focus

KPA	Models					
	EI	EBI	HIERARCHY	EBI2	TDWI	SOBI
Management				X		
Context Application			X			
Change				X		
Content	X					
Convergence of Enterprise Data		X				
Data Marts		X			X	
Data Warehouse		X			X	
Dashboard			X			
Enterprise Data Warehouse		X			X	
Key Performance Key Indices			X		X	
Interpretation			X			
Medios	X					
Expert Systems						
Service Oriented Systems						X
Spread Marts					X	
Technology	X					

MEI model was chosen because it is the only one with an explicit description of all elements such as levels, KPA, objectives, and practices that should compose a maturity model. It also includes three essential dimensions of BI initiative architecture: process, systems, and data. In addition, the MEI model is the only one analyzed that does not show a rigid structure as it varies in the amount of efforts done, according to the difficulty of the transition level in which the organization is located.

Due to MEI characteristics, it should be applied in an organization that has implemented at least three BI initiatives.

Because the concept of Enterprise Intelligence (EI) is broader than BI, it is possible to use an EI maturity model as a BI model, earning greater profits as it not only includes the analysis of data, systems, and processes, but also architecture and knowledge management.

According to [6] "EI is the ability of an organization or company to reason, plan, predict, solve problems, think abstractly, comprehend, innovate, learn in ways that enhance knowledge of an organization, inform the decision-making processes to take effective actions, and help set and achieve business goals".

Table 2 shows the levels and KPA of the MEI model.

Table 2 MEI model structure

Level	Key Process Areas
1) Asset management	Assurance, methodology, engineering, and governance
2) Asset identification	Media, content, and network
3) Asset readiness	Knowledge, resources and expertise, research, and collaboration
4) Asset utilization	Problem solving, decision support
5) Asset leverage	Competitive Enterprise

3. BI maturity states

The methodological guide should include the implementation of improvements in the BI maturity state of activities as the performance of maturity transition from one state to the next one.

The state or degree of maturity of an activity is the extent, to which it is explicitly defined, managed, measured, and controlled [7].

GMM-BI defines five maturity states an activity could perform and the corresponding transitions among maturity states, as shown in Figure 1. The transition of the maturity state will depend on the maturity state of the activity. These five states were defined based on the established by CMMI in this regard.

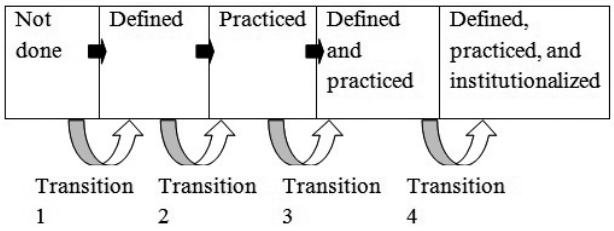


Figure 1 Maturity of BI activities or processes

In general, GMM-BI involves implementing improvements in the maturity state of activities associated to each KPA. However, GMM-BI was instantiated for only one KPA, which was selected according to the characteristics of the organizations to be used as cases of study. In this form, the knowledge KPA was selected, which includes the following activities: Identification of standard knowledge bases; identification of knowledge bases to support competitive practices; and the use of mechanisms to acquire knowledge.

The MEI model only refers to activities, but it does not establish a procedure for the organization to perform them. Therefore, apart from presenting a methodological path, GMM-BI also defines three procedures to enable the organization to implement activities making up KPA knowledge.

4. Framework improvements in BI maturity

Below is a methodological path supporting GMM-BI. This methodological path consists of the following phases: *maturity level determination, result analysis, improvement specification, and improvement implementation.*

The methodological path is circular since it is an iterative process that must be conducted whenever a state transition of maturity for a group of activities is required.

Figure 2 outlines the methodological path as a process flow, describing the order of execution of the four phases and their respective activities.

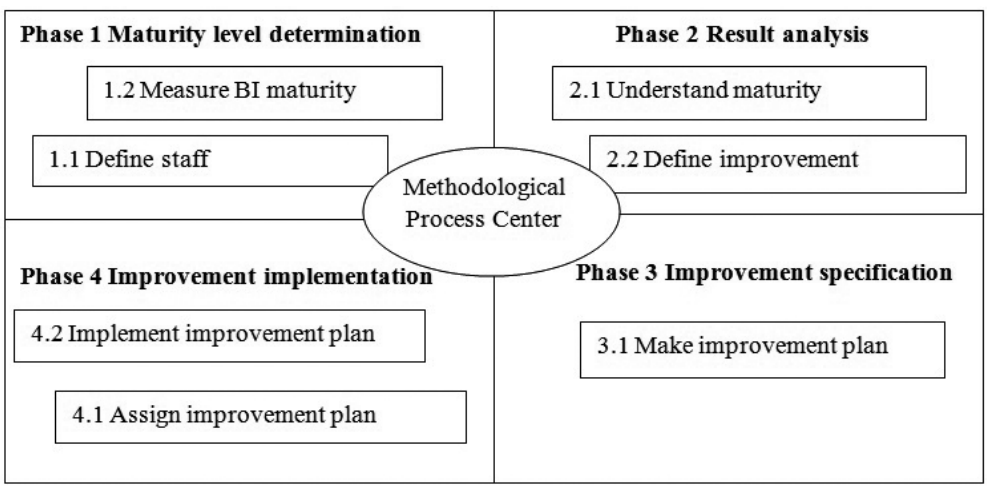


Figure 2 GMM-BI methodological path

4.1. Phase1: Maturity level determination

The first phase defines the individuals involved in implementing GMM-BI. It also evaluates the current Bi maturity level of the organization through the administration of a questionnaire measuring the organizational attitude for MEI model activities.

Figure 3 describes the methodological flow for the phase *maturity level determination*, showing inputs, processes, and their respective outputs.

Table 3 shows the activities and tasks to be performed in the phase maturity level determination.

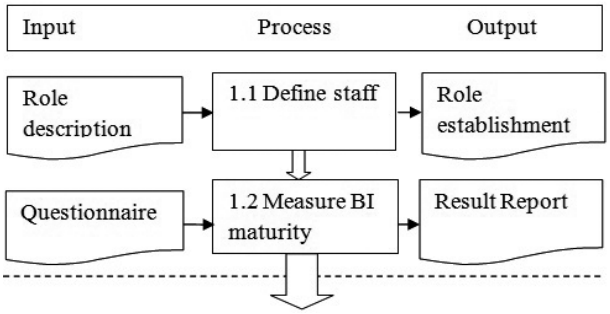


Figure 3 Methodological flow for phase maturity level determination

4.2. Phase 2: Result analysis

This phase should include the global results of an organization and an individual for each activity obtained in administering the questionnaire. It should also define the KPA where improvements in maturity state will be implemented, considering each activity of the KPA involved. Figure 4 describes the methodological flow of the phase result *analysis*, showing the processes and the corresponding input and output.

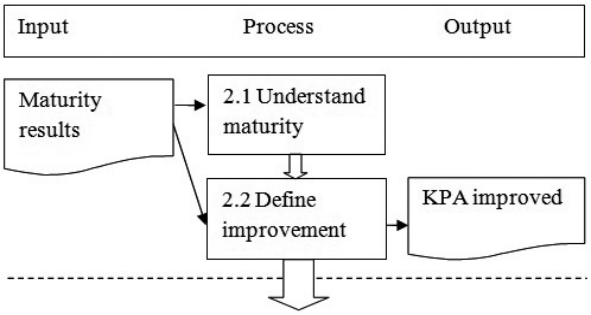


Figure 4 Methodological flows for phase result analysis

Table 3 Activities and tasks of phase maturity level determination

Activity	Tasks	Description
Staff definition	Role characterization	GMM-BI proposes a set of roles. This task refers to conduct a review and selection of these roles, to use as a basis in defining the next task.
	Define roles	This work provides employees must participate in the implementation of the methodology. To do this, a table describing all the roles that are needed is provided. The table also provides a characterization of the functions to be performed by each role. Therefore, responsible for the task shall designate the person who will play each role, based on the information provided in the table.
BI maturity measurement	Complete questionnaire	In this activity the organizational attitude to each proposed process in the reference model is measured. With this information the organization can implement improvements in a specific area. To do this, the head of the task must answer a questionnaire, where the organizational attitude is evaluated against each process. Possible attitudes to be adopted by the organization are: a) it is not performed b) it is defined c) it is practiced d) it is defined and practiced e) It is defined, practiced and institutionalized. Product of this activity, two reports are generated: – Report the level of overall maturity – Detail report for process maturity

Table 4 Activities and tasks of phase result analysis

Activity	Tasks	Description
Maturity understanding	Analyze report on features of the current level	This encompasses the analysis of the "Report of the level of global maturity" generated in the previous stage. It identifies the areas the organization should improve.
	Analyze report on the maturity state of each activity	This encompasses the analysis of the "Detailed report of maturity by process". It provides insight into the state of maturity, in which are the processes of the organization.
Improvement definition	Identify KPA where maturity will improve	Once understood the maturity that the organization currently have, the task leader should recognize the area that must be improved. In the case of this method, the area to improve is the knowledge KPA. Therefore, detailed processes to implement improvements at maturity are the processes of the knowledge KPA. These are: 1. Identification of standard knowledge bases. 2. Identification of bases that support competitive practices. 3. Use mechanism to acquire knowledge.

Table 4 shows the activities and tasks for phase *result analysis.*

4.3. Phase 3: Improvement specification

In this phase an improvement plan should be designed for each KPA activity. This improvement plan should define a particular improvement process. There are four possible improvement processes, depending on the current maturity state of the activity. Every possible improvement process involves activities and tasks previously defined.

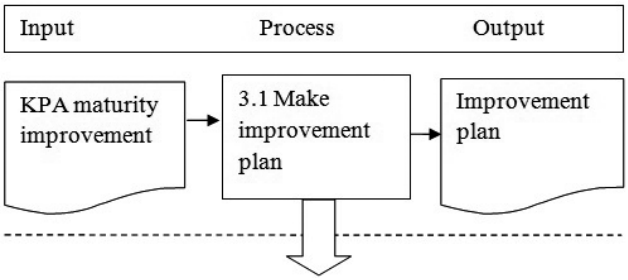


Figure 5 Methodological flows for phase *improvement specification*

Figure 6 describes the possible improvements processes of each improvement plan, depending on the maturity state of the activity involved.

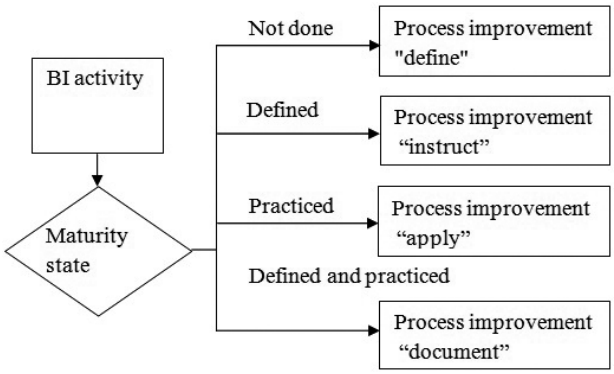


Figure 6 Maturity improvement process

The improvement process is applied to the procedures defined in the GMM-BI so that the organization can perform KPA activities to implement maturity improvements. The improvement processes are defined as follows: instruct, apply, and document.

Table 5 Activities and tasks for phase improvement specification

Activity	Tasks	Description
Designing an improvement plan	Identify the maturity state to assess the activity	From the above steps, it is possible to identify the current state of maturity, which will be the starting point.
	Choose an improvement process	Depending on the current level, the process of improvement required to achieve a level of maturity up is selected. Possible processes are: – Define procedure – Instruct procedure – Apply procedure – Document procedure
	Develop an improvement plan with activities and tasks, including the improvement process chosen	An improvement plan is generated, where activities and tasks to develop, leaders and participants in general are identified.

Table 5 describes the activities and tasks for phase improvement specification.

4.4. Phase 4: Improvement implementation

In the last phase each improvement plan is distributed and implemented. The plan is distributed among the individuals involved in each procedure, based on a characterization of previously established roles. The implementation of the improvement plan allows performing the maturity transition from its current state to the next one.

Figure 7 describes the methodological flow for phase *improvement implemention*, showing the processes and the corresponding input and output.

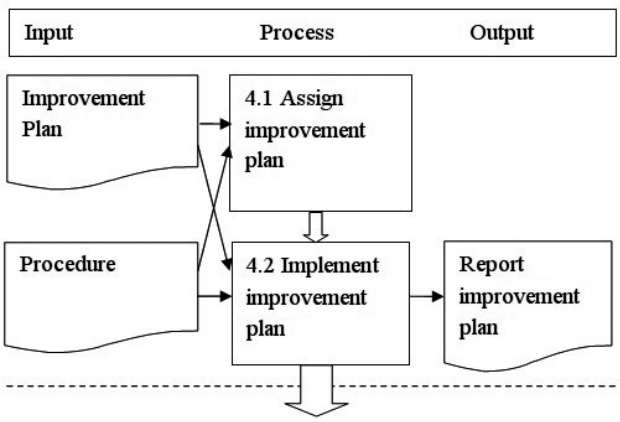


Figure 7 Phase flow of methodological improvement implementation

Table 6 Activities and tasks for phase *improvement implementation*

Activity	Tasks	Description
Improvement plan design	Read role characterization for a an improvement process chosen	The various processes of improvement proposed, incorporating a set of roles to consider. This encompasses the study of these roles to have knowledge of the staff required for the implementation of the improvement plan.
	Identify personnel involved in the improvement process	Once identified the roles required, the project manager is responsible for assigning specific roles to people, and their justification.
	Distribute the improvement plan to individuals identified	The improvement plan is distributed to those identified as responsible for the activities to be performed in the procedure.
Improvement plan implementation	Perform the activities and tasks of the improvement plan	The execution of all activities and tasks present in the improvement plan for each procedure is performed.

Table 6 shows the activities and tasks for phase *improvement implementation.*

5. Determination of BI organizational maturity level

To establish the maturity level of an organization, first the organizational attitude of a set of activities must be evaluated. This set of activities refers to MEI model activities. To evaluate the organizational attitude in each activity a Likert scale is used by administering a questionnaire. Possible organizational attitudes are: *Not done; Defined; Practiced; Defined and practiced; Defined, practiced, and institutionalized.*

For a better result analysis, questions are grouped into dimensions. These dimensions correspond to the MEI model KPA.

Then, the three processes to determine the BI organizational maturity level are presented.

First, a questionnaire for measuring organizational attitude in the 33 activities of the MEI model was administered. Each possible organizational attitude has an equivalent value. Table 7 shows the relationship between organizational attitude and value equivalent.

Table 7 Rating Scale

Organizational attitude	Value
a) Defined, practiced, and institutionalized.	4
b) Defined and implemented.	3
c) Practiced.	2
d) Defined.	1
e) Performed.	0

Second, maturity is quantified by calculating the sum of all the values corresponding to the organizational attitude evaluated, according to Table 5. Eq. (1) is used to set the sum of all values.

$$\sum_{i=m}^{n} S = x_m + x_{m+1} + \cdots + x_n \quad (1)$$

where S is the addition, i is the index of activities from m to n, and x corresponds to the equivalent value of the organizational attitude by the activity evaluated.

Finally, the sum obtained in the previous process is categorized into five possible ranges. Table 8 lists the five possible value ranges.

Table 8 Categorization of BI organizational maturity level

Level	Minimum	Maximum
1	0	24
2	25	52
3	53	96
4	97	120
5	121	132

Eq. (2) was used to calculate the maximum value of each level in Table 8.

$$Max = (N * 4) \quad (2)$$

Where N corresponds to the amount of activity of the MEI model from the initial level to the level considered and numeric constant 4 is the value equivalence of the highest possible organizational attitude.

Eq. (3) was used to calculate the minimum value of each level in Table 8.

$$Min = (MaxPrevious + 1) \quad (3)$$

where *MaxPrevious* is *Max* calculation of the previous level using Eq. (1) and 1 is a constant. As level 1 does not have the previous level, *Min* is zero.

6. KPA knowledge

Although GMM-BI involves implementing improvements in the maturity state of activities associated to each KPA considered, it really was instantiated for the knowledge KPA, which was selected according to the characteristics and interests of the organizations used as case studies. An extensive explanation about how to use GMM-BI and how it was instantiated for the *knowledge* KPA can be found in [8].

In [9], knowledge is defined as "information consisting of organized data and facts. It consists of truths, beliefs, perspectives, concepts, judgments, expectations, methodologies, and know-how". The organization should store the knowledge generated in the bases to use it to its advantage.

According to [10], a knowledge base is "an organized repository of information, which includes concepts, data, standards, and specifications for effective knowledge management. This repository can collect, organize, share, and search information".

Then, a summary of the three procedures developed in GMM-BI is presented to enable the organization to perform the activities composing KPA knowledge.

6.1. Identification of standard knowledge bases

Lessons learned are an important source of knowledge. They are used to replicate successful results or prevent errors. This knowledge is not only relevant for individuals who learn from it, but also for people who generate it [11].

According to [12] knowledge is necessary for people to do their jobs. Therefore, the organization should worry about implementing a lessons-learned log.

The first procedure seeks to be a systematic approach to identify, record, and disseminate the lessons-learned process. This procedure should be complemented with a system for storing lessons learned, facilitating the search.

Figure 8 shows the execution order of the four activities forming the procedure *Identification of standard knowledge bases.*

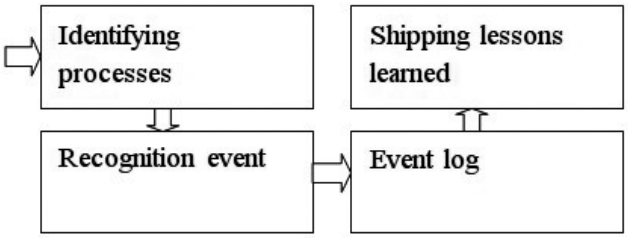


Figure 8 Activities composing the procedure Identification of standard knowledge bases

The activities of this procedure allow the organization to identify processes, being valuable for the organization to register the lessons learned. Then, a structured approach is presented to acquire the knowledge generated by the lessons learned. Later, the recorded knowledge is sent to the human resource performing similar activities.

According to [13], it is possible to combine different types of knowledge. Therefore, lessons learned are represented in a knowledge base describing the possible combinations of the knowledge resulting from the lessons learned.

Table 9 shows the *standard process to identify knowledge bases*. For this purpose, an adaptation of Nonaka's and Takeuchi's SECI (Socialization - Externalization-Combination - Internalization) model was used [14].

Table 9 Representation of the procedure Identification of standard knowledge bases

	Tacit	Explicit
	Socialization	Outsourcing
Tacit	Explain what has been learned	Check the types of events that occurred
	Internalization	Combination
Explicit	Learning the lessons	Sending lessons learned

6.2. Identification of knowledge bases for supporting competitive practices

Organizations currently store vast amounts of data [15]. These data are another important source of knowledge. To use this knowledge, it is necessary to apply existing data mining techniques. The existing data mining methodologies lack a method using diagrams and text for explaining the different stages, ranging from business understanding to data modeling [16].
The second procedure aims to develop a formal process to

identify tacit knowledge bases residing in the databases of the organization to be used as support in implementing data mining projects, complemented by the application of existing data modeling techniques.

Organizations using accumulated experience can create value that enable to reflect, document, learn, and innovate for competitive advantage [17].

Figure 9 shows the execution order of the four activities of the procedure to identify knowledge bases supporting competitive practices.

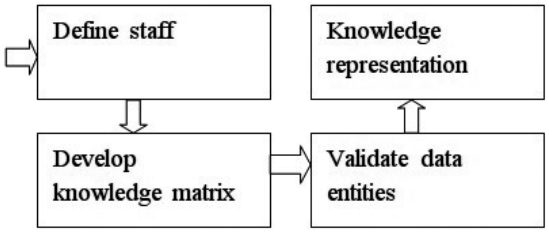


Figure 9 Activities composing the procedure Identification of knowledge bases for supporting competitive practices

The activities of this process enable the organization to identify the resident knowledge in the databases of the organization. First, key roles are identified to establish knowledge needs. Then, to identify individuals a structured questionnaire is administered to define inputs, outputs, and related data entities. Next, historical records are validated and the properties of each data entity are set, as illustrated in a knowledge matrix. Finally, this procedure is rendered in a fact table as a knowledge base. This representation must be supplemented by the application of mining techniques to existing data to generate patterns and use the knowledge identified.

6.3. Mechanism to acquire knowledge

The intellectual capital of an individual to solve complex problems within the organization is another valuable knowledge supplier for the organization.

According to [18] "The only irreplaceable capital of an organization is intellectual capital, given the role played by human resources in the knowledge and skills of the organization".

The third procedure seeks to provide a mechanism to acquire part of the knowledge of experts in solving complex problems of the organization. This knowledge can be exploited to implement improvements or as a basis for the future implementation of expert systems.

According to [19], an expert system is "a system that uses human knowledge captured in a computer to solve problems that ordinarily require human expertise".

Figure 10 describes the sequence of the four activities that make up the procedure used as a mechanism to acquire knowledge.

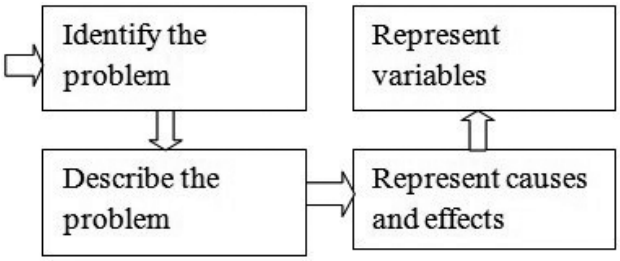


Figure 10 Activities making up the procedure Use mechanism to acquire knowledge

The activities of this process identify the complex problems occurring within the organization, which can only be solved by experts. Then, a structured questionnaire is administered to experts to acquire some of their knowledge in solving complex problems identified. To do this, a questionnaire is administered to set variables, causes, direct and indirect effects, and a characterization of the problem. This knowledge is represented in a tree diagram to create a hierarchy of the causes and effects of the problem.

7. GMM-BI Implementation

To validate GMM-BI application to improve maturity in the activities included in KPA knowledge, GMM-BI was applied in three organizations. These organizations have already implemented more three BI initiatives.

Organization 1 is the port sector with about 1000 workers, including staff and contractors. Organization 2 belongs to the transport sector with nearly 800 workers. Organization 3 belongs to the power generation sector, with 500 workers, including staff and contractors.

GMM-BI application by phase is shown below.

7.1. Application: phase maturity level determination

In the first phase, each organization determined the personnel participating in GMM-BI implementation. This definition emphasizes the determination of the IT Manager role, as this role is responsible for defining the organizational attitude in all activities evaluated.

The application of the proposed methodology was developed with the guidance and participation of internal staff of organizations. In particular, they involved the roles listed in Table 10.

Table 11 shows the sum obtained by applying Eq. (1) to each KPA evaluated.

Table 10 Participants from each organization in implementing the methodology

Role	Description
Chief IT area	Person who is in charge of the IT department within the organization.
Responsible for the methodology	Person that will lead the implementation of the methodology can be the same area IT Manager or another person.
Business expert	The area manager who knows the critical processes across the organization.
IT expert	Person who must know the database tables occupied by different operating systems within the organization.

Table 11 KPA categorization of BI organizational maturity level

KPA	Organization		
	1	2	3
1. Assurance	5	4	2
2. Methodology	3	6	2
3. Media	5	5	2
4. Content	0	1	0
5. Network	3	6	0
6. Knowledge	0	0	0
7. Resources and expertise	0	5	0
8. Research and collaboration	6	2	0
9. Problem solving	0	4	0
10. Decision support	2	2	2
11. Competitive enterprise	0	0	0
Total	24	30	8

Importantly, in this first version of the methodology, it was considered that all key process areas have the same weight in calculating the level of maturity. However, it is currently developing a research project to provide an improvement to the GMM-BI guide, which considers the prioritization or differentiated assessment of various KPA, among other things.

Figure 11 shows the maturity level obtained by the three organizations, according to the total results shown in Table 11. The graph shows that organization 1 has a level of maturity 2, totaling a value of 30. Organization 2 also shows a level of maturity 2, totaling a value of 24. This implies that organizations 1 and 2 have institutionalized practices of world-class knowledge and knowledge architecture. Organization 3 has a level of maturity 1, totaling a value of 8. This means that organization 3 does not have a content management that can understand the knowledge of the organization.

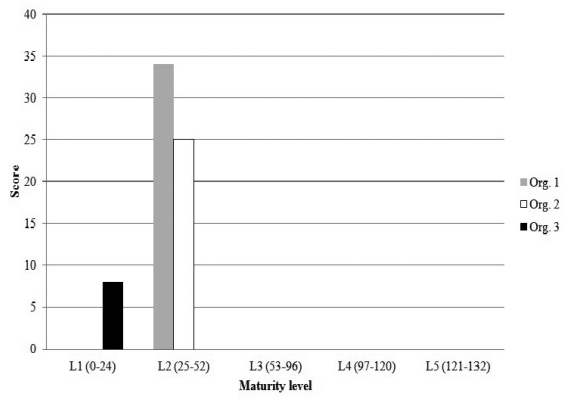


Figure 11 Maturity level categorization

7.2. Application: phase result analysis

For a better analysis, two variables were added in each activity evaluated, i.e., *Minimum* (M) and *Good* (B). The *Minimum* variable establishes the lowest maturity state of an activity within the organization. If the maturity state of an activity is below *Minimum*, the organization should prioritize implementing improvements in the maturity state of the activity involved. For the present application, the variable *Minimum* as the organizational attitude *"Defined"* equivalent to value 1 should be considered. Variable *Good* establishes the acceptable maturity state an activity should have within the organization. Variable *Good* is lower than the highest possible maturity state. For the present application, variable Good should be considered as the organizational attitude *"Defined and practiced"*, equivalent to value 3.

Variable *Real,* corresponding to the maturity state of each activity under evaluation, is added to these two variables. These three variables are used to calculate the *Adequacy* (A) and *Superiority* (S) of each activity assessed. *Adequacy* and *Superiority* will enable the organization to have an indicator to detect the activities that should be prioritized in the implementation of improvements, along with the activities not urgent to implement improvements. *Adequacy* is calculated with Eq. (4).

$$A = Real - Minimum \tag{4}$$

where A is Adequacy calculated from the difference between the Real value obtained from the questionnaire administration and the variable *Minimum* already defined. If *Adequacy* is negative the organization should prioritize the implementation of improvements.
Superiority is calculated with Eq. (5).

$$S = Real - Good \tag{5}$$

where S is *Superiority* calculated from the difference between the *Real* value obtained from the questionnaire administration and the variable *Good* already defined. If *Superiority* is zero the activity in question is not a priority for improvement implementation.

Table 12 shows the sum corresponding to the calculation of certain variables in all activities pertaining to each KPA evaluated. Computed variables are: Adequacy (A)

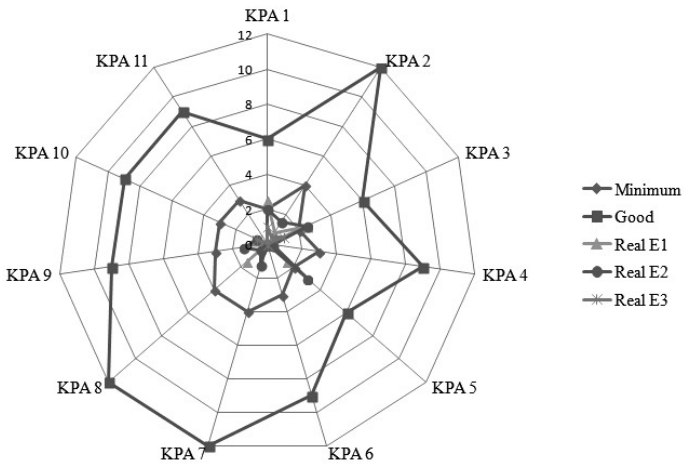
calculated with Eq. (4); *Superiority* (S) calculated with Eq. (5); *Minimum* (M) calculated by multiplying the amount of activities the KPA involved and constant 1 equivalent to the organizational attitude "*Defined*". Variable *Good* (B) is calculated by multiplying the amount of activities with the KPA involved and constant 3 equivalent to the organizational attitude "*Defined and practiced*". The Real variable (R) corresponds to the maturity state shown by each activity under evaluation. All these variables are calculated for organization 1 (01), organization 2 (02), and organization 3 (03).

Table 12 shows that most *Adequacy* occurs in KPA 5 in organization 2 with a score of 1, indicating that the maturity states of the activities belonging to KPA5 are above the lower limit defined. In turn, *Superiority* shows negative values in the three KPA of the organizations. This means there is no KPA that transfers or equals the upper limit defined. Most *Superiority* occurs in KPA N° 5 with a score of -3 in organization 2.

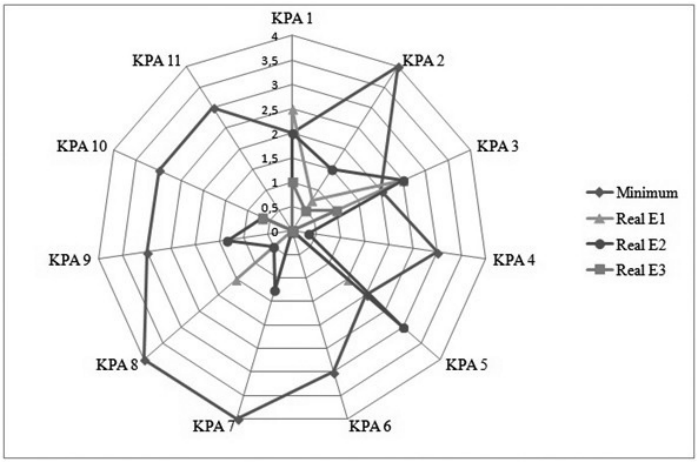
Figure 12 shows the maturity state of each KPA with respect to the upper and lower limits defined. Most KPAs do not cross with the lower limit, with the exception of KPA 5 in organization 2, but this KPA is far from the upper limit.

Table 12 Categorization of BI organizational maturity level

KPA	M	R(01)	R(02)	R(03)	B	A(01)	S(01)	A(02)	S(02)	A(03)	S(03)
N° 1	2	2.5	2	1	6	0.5	-3.5	0	-4	-1	-5
N° 2	4	0.75	1.5	0.5	12	-3.25	-11.25	-2.5	-10.5	-3.5	-11.5
N° 3	2	2.5	2.5	1	6	0.5	-3.5	0.5	-3.5	-1	-5
N° 4	3	0	0.333	0	9	-3	-9	-2.667	-8.667	-3	-9
N° 5	2	1.5	3	0	6	-0.5	-4.5	1	-3	-2	-6
N° 6	3	0	0	0	9	-3	-9	-3	-9	-3	-9
N° 7	4	0	1.25	0	12	-4	-12	-2.75	-10.75	-4	-12
N° 8	4	1.5	0.5	0	12	-2.5	-10.5	-3.5	-11.5	-4	-12
N° 9	3	0	1.333	0	9	-3	-9	-1.667	-7.667	-3	-9
N° 10	3	0.66	0.66	0.66	9	-2.34	-8.34	-2.34	-8.34	-2.34	-8.34
N° 11	3	0	0	0	9	-3	-9	-3	-9	-3	-9



(a)



(b)

Figure 12 Organizational charts for each KPA attitude. (a) With upper and lower limit. (b) With upper limit removed

7.3. Application: phase improvement specification

The three organizations have the same improvement plan since they obtained the same results in the evaluation of KPA knowledge activities. This improvement plan involves the accomplishment of the tasks defined for the improvement process "definition". These tasks aim to formalize the use of a procedure to perform the corresponding activity. For this reason, the procedure considered should be presented, reviewed, modified, and approved to meet the needs of the organization.

7.4. Application: phase improvement implementation

In this phase each task defined in the improvement process of the previous phase is performed. Next, the attitude of the organization in the KPA related to improvements implemented in the maturity state is re-evaluated. The implementation of these improvements enables the transition from the maturity state *not done*, equivalent to 0, to the next state, *defined*, equivalent to 1.

Table 13 shows the value equivalence of organizational attitude presented by KPA knowledge activities before (N) and after (D) the implementation of improvements in the three organizations. Table 11 also shows that the three activities before GMM-BI implementation present a maturity state "not done". Therefore, organizations apply GMM-BI, providing a base procedure to conduct the activities involved and a reference framework to review and change the base procedures, according to the needs of each organization.

Table 13 Summary of maturity improvement activities in KPA knowledge

Activities	Act. 1		Act. 2		Act. 3	
	N	D	N	D	N	D
Identification of standard knowledge bases	0	1	0	1	0	1
Identification of knowledge bases to support competitive practices	0	1	0	1	0	1
Use of a mechanism to acquire knowledge	0	1	0	1	0	1

8. Conclusions and future work

This paper shows that, in applying the methodological tool GMM-BI, it is possible to implement improvements in the maturity state of a group of activities. This is shown in Table 13.

This is possible, first, because GMM-BI defines the maturity states for BI activities, allowing the evaluation of the maturity states in such activities. Second, the framework presented by GMM-BI sets the execution order of the activities to be performed by the organization to help implementing maturity improvements for a group of activities. Third, since GMM-BI defines the procedures of the three activities making up the KPA involved, the organization can be instantiated of the GMM-BI in KPA knowledge, regardless of the maturity states each KPA knowledge activity presents.

Concerning KPA knowledge activities, the activity identifying the standard knowledge bases provides the organization with a procedure to identify activities, allowing the organization to avoid or improve efforts in certain processes.

Moreover, the identification activity of the knowledge base supporting competitive practices enable the organization to design diagrams with the resident knowledge in the databases of the organization. This knowledge base complements existing data modeling that enable the extraction and later use of data mining.

The last activity, use of a mechanism to acquire knowledge, extracts the knowledge from the human capital of the organization, that is, experience, expertise, and ability to solve complex problems within the organization.

In summary, by applying GMM-BI, an organization can know and improve its current BI maturity, allowing it to evaluate improvements in a specific area and make comparisons with its competitors.

A review of the GMM-BI guide from a critical point of view has allowed identifying some aspects that may require improvement and are being investigated in further research works. For example: the selection of the base maturity model should be revised in order to evaluate whether a combination of quantitative with qualitative methods may produce a different ranking of maturity models; some assumptions (e.g., all KPA considered weigh the same) may be removed in order to improve the guide adaptability to specific cases; incorporate templates of projects to be performed as part of the improvement plan; and so on.

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