AHP and SMART Criteria for KPIs Selection in Higher Education: case of candidates' selection process

ABSTRACT

Identifying and choosing the most pertinent Key Performance Indicators (KPIs) has a crucial impact on decision making: if the wrong KPIs are measured, or if they are measured in the wrong way, the information may be misleading and the quality of decisions can be significantly affected. Choosing appropriate KPIs requires a deep understanding of the organization. Moreover, a successful selection of appropriate KPIs relies on a number of well-defined criteria. We propose in this paper a new approach to facilitate the structuring, and/or synthesis of a set of specific, measurable, attainable, realistic and timebased KPIs (SMART KPIs) based on the Analytic Hierarchy Process (AHP) method. The approach steps are illustrated and validated with a real case study. This case study is related to the candidates' selection process in a Tunisian higher education institute.

Keywords: Key Performance Indicators, Business Process Management, Analytic Hierarchy Process, SMART criteria, Candidates' selection Process, decision making, Business Process improvement.

INTRODUCTION

Multi-criteria decision making (MCDM) is a process for making decisions in the case of multiple, often conflicting, criteria. Many areas use multi-criteria decision making as a useful technique. (Gavade, 2014).

Performance measurement criteria, i.e., performance metrics or KPIs, are often used in a variety of domains to either reveal performance deficit or improve a certain process (Shahin & Mahbod, 2007). In the literature, it is recommended that KPIs satisfy the SMART criteria Doran, 1981)(Shahin & Mahbod, 2007) and we consider crucial to use one of the most popular methods

for multiple criteria decision making such as the Analytic Hierarchy Process method (AHP)(Podgórski, 2015). The purpose of this research is to assess the quality of indicators by comparisons and to set priority areas for additional KPI development or improvement.
The improvement in performance is based on an efficient definition and selection of appropriate measurements. The method is used successfully in many areas (hotel case study (Shahin & Mahbod, 2007), occupational safety and health management systems (Kerzner, 2017), enterprise analysis model (EAM) process (Yaghoobi & Haddadi, 2016), a telecommunications industry case (Peral et al, 2017) higher education institution (Amole, 2016), public teaching hospitals in Southwest Nigeria (ORTEGA, 2012)). In the Business Process Management research area, the concept of Business Process (BP) is essential since it serves to understand how a business operates and what opportunities exist for making its activities more efficient (Dumas et al, 2013). In addition, Dumas et al. note that time, cost, quality, and flexibility are the typical performance perspectives of BP performance measurements.
The AHP method includes a multi-criteria decision and it seems very suitable to our selection problem for many reasons.
First, it permits reaching an agreement on a coherent set of KPIs that do not conflict but ideally support business process goals and that meets the needs of as many stakeholders as possible, with subjective judgments from a decision-maker or an expert. Second, the few numbers of criteria (SMART) are considered in this work as appropriate to structure the decision maker's mind in order to provide a systematic prioritization of sustainability performance indicators. Third, we don't need an absolute scale that requires much domain experience but relative values (e.g. less/more; somewhat, very) in opposition to classical measurement. Fourth, the AHP method allows to keep in our approach a logical consistency of the judgments used to detect when KPIs preference is inconsistent. Fifth, the main point offered by AHP related to the relative priority of each criterion to obtain the best KPI according to the identified business process goal and the synthesis provides a general assessment of the desirability of each KPI.
The need for a methodology in selecting KPIs for business process analysis has been increasing. The reason is that business process analysis seeks to determine what to measure in order to improve KPIs and business processes. Moreover, this selection is generally contextual where the lack of understanding of the performance measures leads to a failure in monitoring and reporting of measures.
Thus, the following research challenges are considered in this paper
- How to provide a methodological support for discovering KPIs and enhancing the definition of existing once?
- How to ensure that indicators are SMART?
- How to cover quantitative and qualitative aspects in the evaluation of performance?
In our approach, we adopt the AHP method with SMART criteria, which are combined to move from a first KPI list to an advanced SMART KPI list. In addition, we are not only enhancing process measurement definition; but also ensuring that KPIs fulfill the requirements of the BP and then eliminate inappropriate KPIs or discover other indicators. In turn, the use of this method in the BPM design phase offers more consistent indicators tailored to our BP. Thus, the BPM lifecycle is completed by integrating into its design phase a sub-cycle dedicated to selecting appropriate KPIs and enhancing them based on the AHP method.
Furthermore, to evaluate our approach, we have presented its main results in a real-world case study. Especially this case study is related to the candidates' selection process in a Tunisian

higher education institute. In this case study, we apply our approach for detecting appropriate KPIs to stakeholders based on an optimum SMART definition for KPIs.
The remainder of this paper is organized as follows. Section 2 introduces the basic concepts relevant to our research. Section 3 describes the motivating scenario. Section 4 presents related work. Section 5 gives an overview of the proposed approach. Section 6 describes the application of our approach in the higher education case study. Section 7 presents a discussion for comparing our approach to related work. The last section gives a brief conclusion.

2 THEORETICAL BACKGROUND

Multi-criteria analysis methods are often classified on the basis of the set of possible alternatives. There are discrete and continuous methods depending on the scope of the alternatives. The first ones deal with a generally limited and pre-specified number of alternatives. The second one deals with variable decision values determined in a continuous or integer domain from a very large or infinite number of choices (Guizani & Ghannouchi, 2021).
To make a decision requires that there are alternative choices to be considered and in this case, , we will not simply identify as many alternatives as possible, but select the one that best fits our goals, preferences, values, etc. (Gavade, 2014). The author in (Gavade, 2014) presents an overview of Multi-Criteria Decision Making method summarized in table 1.

Table 1. Summary of MCDM Methods

Method	Strengths	Weaknesses
Analytic Hierarchy Process (AHP)	Pairwise comparisons offer a simple way to capture qualitative preferences.	A greater number of pairwise comparisons is needed for large-scale problems.
Technique of Order Preference by Similarity of Ideal Solution(TOPSIS)	Has an easy process; simple to use & program; number of steps are the same whatever the set of attributes.	The use of Euclidean distance does not take into account the correlation of the attributes; it is difficult to weight and keep the judgment consistent..
Simple Additive Weighting (SAW)	Ability to balance between criteria; easy for decision-makers to understand; no complicated computer programs needed for calculation.	the obtained results may not always reflect the real situation and may not always be logical
PROMETHEE	User-friendly; no need to consider the proportionality of criteria.	Lacks a clear method for attributing weights.
ELECTRE	Takes into account both uncertainty and imprecision.	Its outcome and process may not easily be explained in layman's terms; over-ranking means that the strengths and weaknesses of alternatives are not directly identified..
Goal Programming (GP)	Ability to solve large-scale problems; can generate an infinite number of alternatives.	Should usually be used in conjunction with other MCDM methods for weighting coefficients
Simple Multi-Attribute Rating Technique	Easy; permits any type of weight allocation technique; requires minimal effort on the part of decision makers.	Process may not be practical considering the framework.
Data Envelopment Analysis (DEA)	Able to handle multiple inputs and outputs; efficiency can be analyzed and quantified.	Does not handle imprecise data; supposes that all inputs and outputs are exactly known.
Case-Based Reasoning (CBR)	Non-data intensive; low maintenance; ability to improve through time; able to adapt to	Sensitive to conflicting data; many cases are needed.

	changing environment	
Multi-Attribute Utility Theory (MAUT)	Incorporates uncertainty; can include preferences.	Requires many inputs; preferences must be accurate.

In our work we focus on the adoption of AHP method which allows decision-makers to measure the consistency of their decisions (Shahin & Mahbod, 2007). It was proposed by Saaty in 1980 and designed to develop overall priorities for ranking the alternatives with respect to several criteria. In fact, it can measure and synthesize the preferences for various factors and alternatives. The application of the AHP method is based on the following three steps:
1-Defining the problem and creating a hierarchical model of decision problems: the method starts with the definition of the main goal to reach the top level. From there, it breaks down this goal into a structured hierarchy of evaluation criteria and sub-criteria through intermediate levels. At the lowest hierarchical level, we find alternatives to evaluate. Figure 1 shows a global view of such a hierarchy.

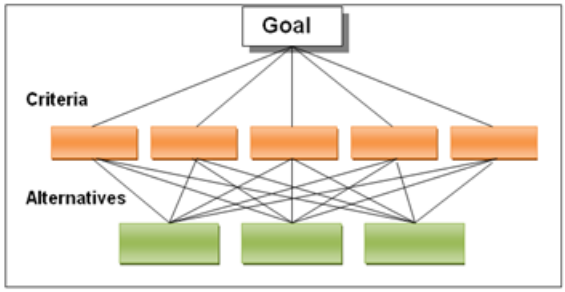

Fig. 1. A global representation of an AHP decision hierarchy

2-Comparing the relative importance of the elements of the hierarchy by making a series of judgments: AHP uses pairwise comparisons based on the Saaty scale. It proceeds by two-to-two combinations of elements of each hierarchical level relative to the elements of the higher level. When we fill a pairwise comparison matrix, we try to answer two main questions: Which criterion/alternative is more important with respect to the goal /criterion? And how important is it? To facilitate decision-maker judgments about the relative importance of criteria and alternatives, there are three judgment elicitation modes (verbal, numerical, or graphical) offered by the AHP method. Hence, a nine-point scale proposed by Saaty that represents how many times one element is more important than another is shown in Table 2.

Table 2. Ranking Saaty scale for criteria and alternatives

Numerical values	Explanation of preferences
1	Equally preferred
3	Moderately preferred
5	Strongly preferred
7	Very strongly preferred
9	Extremely strongly preferred

3-Once the matrix of pairwise comparisons has been developed, we pass to establishing priorities (i.e., weights) for each node of the hierarchy (priority of each alternative under specific criteria, a priority of each criterion under the overall goal) being compared. The AHP method checks the

inconsistency in the judgments and provides a way to improve consistency (Podgórski, 2015). The measurement of the consistency is done by computing a consistency ratio (CR). If the value of the CR is greater than 0.10, the inconsistency is high and then the decision-maker should revise the pairwise comparison judgments, else, the decision process can continue.
All these steps can be accomplished by using a software package for decision support such as Expert Choice.
The definition of criteria and the calculation of their weight are central in the AHP method to assess the KPIs (alternatives). Each indicator should be based on criteria that make it suitable for further analysis. Reviewing the literature, it is found that SMART (or rather SMARTER) criteria are most often referenced. In fact, they are recommended by many professionals in the domain of performance management systems (Kerzner, 2017). The SMART rule was originally developed for establishing meaningful objectives for projects and later adapted to the identification of metrics and KPIs (Kaganski, 2016). There is no clear consensus about what the five SMART keywords mean. Table 3 presents the meaning of SMART criteria as proposed in the literature.

Table 3. The meaning of SMART criteria

SMART Criteria	Meaning of the criteria		
	Ref (Kaganski, 2016)	Ref (Yaghoobi & Haddadi, 2016)	Ref (Maté et al, 2017)
Specific	The KPI is clear and focused toward performance targets or a business purpose.	Goals should be as specific as possible. Taking into consideration a clear understanding of what KPI measures, should be realized.	It has to be clear what the KPI exactly describes and the context within which it is defined.
Measurable	KPI can be expressed quantitatively.	Each objective, process or KPI should be measurable. The measure itself could be quantitative or qualitative, but measurement shall comply with standards and requirements, depending on the main goal.	It has to be possible to measure a current value and to compare it to the target one.
Attainable	Targets are reasonable and achievable.	Objectives should be set at right level. Each KPI should have the standard value that should be achieved.	It makes no sense to pursue a goal that will never be met.
Realistic or Relevant	KPI is directly pertinent to the work done on the project.	KPIs should provide insight into the performance of the company in obtaining its strategy.	It must be aligned with a part of the organization's strategy, something that really affects its performance.
Time-Based or Time-Specific or Time-Sensitive	KPI is measurable within a given period of time.	Each KPI has meaning if everyone knows the time frames in which it is measured and realized.	A KPI only has a meaning if the time period in which it is measured is known.

3 Motivating Scenario

This section introduces the real scenario that motivated our research and to which our approach has been applied. It deals with the candidates' selection process in a Tunisian higher education institute. The selection of the right master candidate is an important step in a successful Master's program. The Master degree considered in this work is named Information System and Decisional Support (ISDS). The BPMN diagram in Fig.2 describes a simplified version of this process.

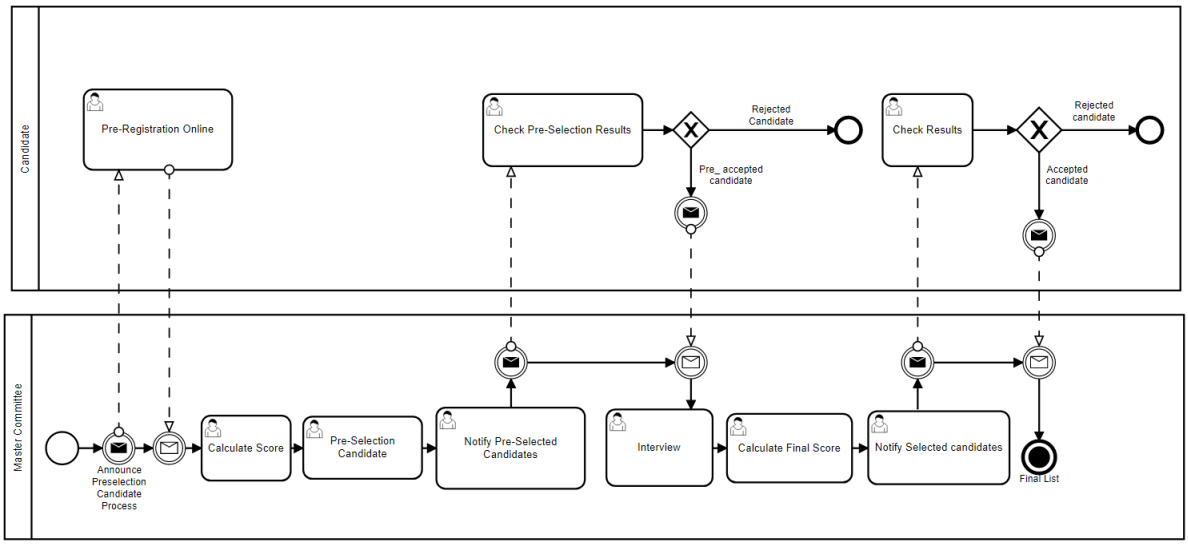

Fig. 2. Candidates' Selection process

There are two main stakeholders in this business process: first, the candidate and, second, the Master's committee. At the design time, we use a graphical container named "pool" for partitioning a set of tasks from other pools. This business process might start in the Master's committee pool that announces the Master's degree opening. Then, the candidate pool might start the online pre-registration. After that, the Master's committee calculates scores for each candidate and decides which candidate is pre-accepted (or not). As soon as the notification date is due, the candidate checks the preselection result. At this level, if the candidate is accepted he is invited to an interview. The interview task sets up the profile of an ideal master candidate. Thereafter, the Master's committee calculates the final scores of each candidate and notifies the selected candidate. There are two cases, which end this process: If the candidate is accepted, the Master's committee prepares the final list of accepted candidates. Else, the candidate is rejected. In fact, this process aims to match the appropriate students who have a license diploma from the High Institute of Management of Sousse or from other institutes to join ISDS Master's degree in the higher institute of management. For reducing the waiting time in this business process and improving the quality of interviews from the point of view of the interviewed candidates, the most pertinent KPIs should be selected.

The data was collected through interviews with the candidate and analyzed with the Master's committee. The purpose was to (i) identify business process goal, (ii) model the candidate selection process, (iii) identify and develop a list of KPIs and determine the associated target values, (iv) develop a set of qualitative indicators based on a questionnaire of candidates's satisfaction. Questions in the questionnaire are formulated according to Likert scale. Moreover it was needed to have an authorization from the administration to get some information about e.g.,

the number of personnel assigned to the pre-selection activity, the number of all preselected candidates, the number of interviewed candidates this min score retained, etc.

4 Related Work

Numerous research works have dealt with the resolution of choice problems in a multi-criteria environment using the AHP method. This section aims to explore how the AHP method is adopted in related works, and, particularly, how the criteria and indicators are defined and measured. Linked to our research challenge, only rare works explicitly address the problem of choosing and improving KPIs under a set of criteria.

Listed below are some important works that have motivated the development of a new algorithm and capitalization of knowledge to deal with the problem of KPIs selection.

According to Shahin et al. (Shahin & Mahbod, 2007), if applying the AHP-SMART method, KPIs can both be prioritized and evaluated to decide which are more "SMART" than others. Shahin et al. suggest an integrated approach to the AHP and SMART criteria for prioritizing KPIs where a case study was conducted in a hotel area (Shahin & Mahbod, 2007). However, the author's approach is only used for prioritization and therefore it is supposed that the selected KPIs are already relevant. In the work of Podgorski et al. (Kerzner, 2017), the composition of initial sets of PPIs subjected to prioritization was based on a review of selected literature on safety performance indicators, and thus it was a priori assumed that all indicators were relevant. However, that hypothesis requires a careful verification, profound analyses and consultations with experts and managers for a given area. In (Yaghoobi & Haddadi, 2016), Kaganski applies the Fuzzy AHP method to reduce the time and eliminate confusion in case of large matrixes. But in this work, they do not provide the final results corresponding to the KPIs prioritization because the comparison matrixes would be completed by experts and they lack for more details according to the choice of KPIs. In (Guizani & Ghannouchi, 2021), the author present an approach for choosing the business process modeling language by the application of the AHP method.

There are many works focused on integrating Balanced Scorecard BSc, and the work of yaakoubi (Peral et al, 2017) is one of them. The results presented in (Peral et al, 2017) are able to help the organization to evaluate and revise its strategy (not revise the KPI). In addition, this method ignores contributions that employees, suppliers, and stakeholders make to help the company achieve its objectives.

According to Suryadi (Amole, 2016), KPI Scoring is based on decision rule. In fact, KPIs are measured based on principles of trends and comparison dimensions. However, the KPI pairwise comparison under each criterion are not clear and also the Wheel model for HEI Performance and its KPIs are not clear. In (ORTEGA, 2012), Amole et al., investigate the use of AHP in estimating determinants of patient satisfaction towards service quality delivery of public teaching hospitals in Southwest Nigeria. They use AHP-based approach to measure the quality of service (e.g. Effective communication and Waiting time) rendered by the hospitals from the patient's perspectives. The questionnaire used in this paper revealed that the majority of respondents (patients) were female. As a consequence, if we change the Socio-demographic component like age, gender, marital status, and education, or change the medical and paramedical staff availability or team, all this aspect related to the relationship between patients' expectations and experiences of the received treatment will also change. This can have an influence on the determination of the priority weight for service quality dimensions and ranking of KPIs.

In (Resinaset al, 2014), Del-Rio-Ortega use indicators that are previously supposed SMART and the author just filled all necessary fields in the template. For example, for the field Goals connecting to the Relevant characteristic, there is no guarantee that this KPI contributes really to evaluate the process performance. So the relevance of KPIs should be evaluated from the expert point of view. The goal of a KPI challenge in the work of Resinas et al.,(Maté et al, 2017) is to complete the description of a KPI that fulfills some operational and/or strategic goal set by the user that raises the challenge. However it presents some limitations that need to be addressed, such as dealing with a potentially unclear or conflicting understanding of KPIs and the way they are defined. Such disparate views can occur when KPIs are interpreted by different people in different business situations. This template is applied only for the quantitative indicator, where the qualitative indicators are not supported.
In (Van Der Aalst et al, 2016), Mate et al., define KPIs by using a modeling language where decision-makers specify KPIs using business terminology. The main problem treated in their paper is that the decision-maker lacks an adequate view to verify that the business strategy and the KPIs are consistent with each other.

5 The Proposed Approach

In the Business Process Management (BPM) design phase, we analyze KPIs currently in use and identify if it is necessary to define new KPIs for the defined business process goals. After that, we move on to the definition of KPIs, these steps respect business-level knowledge and may include qualitative and quantitative indicators. Furthermore, the use of qualitative defined measurement is essential for evaluation and improvement. On the one hand, the qualitative indicators are a broad field which is neither simple to define nor to measure. In fact, we focus especially on improving satisfaction which has become an integral component of effective business process delivery. On the other hand, quantitative indicators facilitate the capture of business process as a quantitative measure of the activities involved. The development of the two aspects offers a powerful vision to business managers and process analysts as well. In this phase, we essentially adopt the AHP method and SMART criteria.

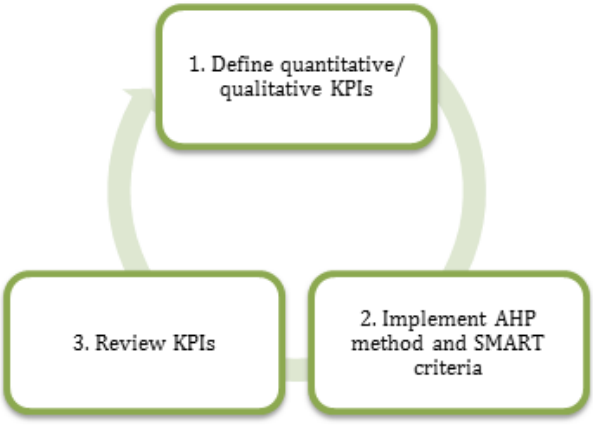

Fig. 3. The proposed approach

In the proposed lifecycle described in Fig.3, we essentially deal with various measurements related to the business processes. We will also deal with two different aspects: qualitative and quantitative. In each aspect, we define and validate the appropriate indicators with different stakeholders of the business process, these measures are based on their intensive knowledge,

experience, and preferences and should have a significant impact on the organization. There are two hierarchical decision models, one for the quantitative indicators and the other for qualitative indicators.

In the second phase and the third phase of our proposed life-cycle (Fig.3), we developed a new algorithm. The use of this algorithm for KPI definition and improvement is crucial prior to their actual implementation.

The proposed algorithm enables users to refine their definition of a problem and to improve their judgment and understanding through repetition; and thereby makes a positive contribution not only to the ranking but also to get an optimum SMART definition for KPIs. Variables and methods used in this algorithm are defined in Listing 1.

SMART_criteria: a set of criteria
KPI_alternatives: a set of alternatives
NK: the number of KPI alternatives
NC: the number of criteria
i, j: a pair of alternatives
M: pairwise-comparison matrix (n×n matrix) (reciprocal matrix)
Cij: the value obtained by comparing criterion ci compared to criterion cj.
KPIij: the value obtained by comparing KPIi relative to KPIj.
CR: Consistency Ratio measured by AHP method and displayed in pair-wise comparison using Expetchoice tool to see the overall consistency of judgment
Update_KPI_set: a predefined method where the user can delete an existing KPI or add a new KPI to KPI alternative set.
Display_criteria_synthesis_under the _goal and
Display_particular_alternative_synthesis_under_particular_criteria: predefined methods which used the eigenvalue method to calculate the relative weights of elements in each pair-wise comparison matrix.
Diplay_synthesis_under_all_criteria: the predefined method referring to the aggregation of relative weights of decision elements to obtain an overall rating for the alternatives.

Listing 1: Variables and methods definition

We create two functions named Compare SMART Criteria and Compare KPI alternative. In the first function, the comparison matrix is formed by repeating the process for each criterion. In the second function, the comparison matrix is formed by repeating the process for each alternative. Responses to the pair-wise comparison question use the nine-point scale (Saaty scale). For example, if criterion ci is absolutely more important than criterion cj and is rated at k= 9, then cj must be absolutely less important than ci and is valued at 1/9. The entries satisfy the following constraint: cij .cji = 1.

We create two functions named Check SMART Matrix Consistency and Check KPI Matrix Consistency. These functions verify if the judgment matrix (under goal or under particular criteria) is inconsistent and the entries that are given by the decision-maker have to be revised until a satisfactory consistency ratio is obtained. We create a procedure named Improve KPI. In this procedure, the user can fulfill the alternative matrix with respect to the criteria, check the consistency of his judgments and based on the synthesis s/he can improve KPIs under a particular criterion. The algorithm (Listing 2) starts after constructing the hierarchy and enriches pair-wise comparison.

```
                                        Algorithm
Var
Response: string
i, j: integer
Begin
Compare_SMART_Criteria (cij)
Check_SMART_Matrix_Consistency (M)
Display_criteria_synthesis_under_goal ();
Repeat
        PRINT "do you think that you set and evaluate the final list of SMART KPIs"
READ (Response)
CASE  Response  OF
        "yes": skip
        "no":Improve_KPI (KPI alternatives)
ENDCASE
Until response= "yes"
Display_synthesis_under_all_criteria ()
End
```

Listing 2: The proposed algorithm

6 Evaluation

In this case study, there are many considerations that we should always keep in mind:
-Select the most important quantitative KPIs related to the business process For example, improving the time it takes to notify candidates about the final results is a process improvement which may improve learning because the research Master's program can start on time.
-Select the most important quantitative KPIs from the administrative file. For example, the minimum score retained from pre-registered candidates which may represent revisable, reviewable or reusable indicators. The improvements using this indicator can guarantee the high qualification of the student and then the quality of the dissertation in the final year of such program.
-Select the most important qualitative KPIs related to students' experiences such as the questions are unclear or discussion does not serve a purpose during the interview. The improvement of qualitative indicators may increase the time spent on relevant issues and increase in-depth questioning and discussion.

6.1 KPI definition for Candidates' Selection BP

After understanding the core business process requirements we can use various KPIs. The choice of KPIs involves domain experts and they should reflect the main objectives of the business process. First, for the candidates' selection process, knowledge, skill, and other abilities are measured and a score is calculated for each candidate. Second, increasing process efficiency is also important and it is based on the extraction of possible indicators values from log files. Typically, log files are generated during the BPM enactment phase and used to store information about processes real execution. For example, we can measure cycle time, waiting time and resource utilization. Third, for increasing student satisfaction, evaluating the business process using qualitative indicators should be ensured, so that we can check if the process meets the needs and expectations of the students. For example, indicators related to a qualitative evaluation of ISDS Master's degree interview. By measuring this type of indicators, it is expected that bottlenecks in the business process are discovered and hence can be solved. Typical indicators

belonging to this domain are waiting time and time between two activities, e.g., interview activity and notification activity. In this case study, the duration of some activities, for example, that of the pre-registration activity is not important regarding the business goals. More specific indicators related to the right choice of the available candidate are critical and play an important role in reaching business goals. Therefore, we advocate a focus on the global indicators, e.g., minimal score retained rather than on its detailed measures such as indicators related to good degree results in undergraduate studies. In fact, we determine the level of detail of our indicators according to the strategic objective of the business process. For this, a generic indicator would be enough and it makes sense to select the candidate, as long as it is possible to distinguish value-adding from non-value-adding during the score retained: first, from pre-selection activity based on proof of academic qualifications; and second, during the score retained based on the interview activity. These two indicators provide a baseline profile of the knowledge and skills of students. Once the committee member decided, which candidates are accepted, a more concrete measurement of knowledge is required for conclusive evidence. For this reason, we set qualitative indicators related to the experience of students during the interview. This kind of qualitative indicators may be more difficult and time-consuming to quantify. For this reason, we use a Likert scale for the five first questions to evaluate student satisfaction. The rest of the indicators play a much more integrative role for the improvement of business process from candidate experience surveys.

The main advantage of setting these indicators is to help the Master's committee to understand the shortcomings in the business processes from another point of view and to make sure to get an unbiased decision, e.g., to be sure for each candidate interview, that there are at least one experienced member and a person who does not have an interest in selecting the candidate. These qualitative indicators open feedback and input from other actors as well as the ability to collaborate, negotiate in an understandable and effective way.

6.2 Integration of AHP and SMART criteria for Indicators

In this section, we describe the pairwise comparison and revision of quantitative and qualitative KPIs under each criterion.

1-Pairwise comparison and revision of quantitative KPI under each criterion:

At this stage, the goal of applying the AHP method and the revision process is to discover which KPI is the most important in the candidates' selection process. In turn, we can validate, discover, or add other indicators previously defined. For example if we start from the KPI "min score required from a preregistered candidate", we can find means to improve/replace it based on questions like: is it important to also have an indicator related to maximal score or average score? is it important to also have KPIs specific to various undergraduate studies (e.g. applied license, fundamental license) or to various institutes. In this way, the revision process when setting KPIs weight in the pairwise comparison helps business analysts and expert analysts in keeping a proper improvement plan for current and future indicators measurements.

For realistic criterion, the Master's committee is interested in all indicators related to the fact that the work is well done, because it will reflect the quality of the selection of candidates. So, they give more importance to the minimum score retained than the number of candidates. As we can see, the minimum score retained from preregistered candidates is in the first rank because all other indicators depend on this indicator (e.g., the number of all preselected candidates depends on this min score retained). The minimum score retained from pre-accepted candidates is also equally important because it has an influence on the number of interviewed candidates and in

turn on the number of final selected candidates. If the min score and the number of candidates are relevant, then the third group of rated indicators are the waiting time between two fixed activities and the max of the candidates' selection process duration. Now let us move on to set preference under "Specific" criterion, for example, the indicator related to the number of pre-selected candidates who have a fundamental license is moderately more important than the indicator related to the minimum score retained from a preregistered candidate, because this indicator is not clear enough and maybe it needs a reformulation in reviewing indicators step. For example, if this indicator is generic, we can adopt "the minimum score retained from a preregistered candidate who has a fundamental license".

We can see that the waiting time from interview activity to the notification activity is moderately more important than the indicator related to the min score retained from the pre-accepted candidate. This indicator is not clear enough about the pre-accepted candidates e.g. is this candidate from the higher education institution or from other institutes? Is the candidate holding an applied license or fundamental license?.

Quantitative indicators retained from administrative files have a mathematic formula and quantitative indicators related to the business process execution can be retrieved from the available log files. For example, the number of preselected candidates can be associated with the number of instances, since an instance of candidates' selection process represents a candidate. All quantitative indicators are measurable. Therefore, they are equally important.

KPIs must be associated with target values, i.e., it is important to set the target value from the time the preselection is started to the time it is approved or rejected. These targets should be determined in line with business process goal. Under the "Attainable" criterion, it is easier to determine if the targets of indicators are acceptable and reachable. Higher education institutions should respect the target values announced about the notification results. For this reason, indicators related to time dimension are the first highest ranked group. Then the number of pre-registered candidates is the fourth-ranked indicator. Based on the final ranked list, we try to answer questions such as how to improve the process in order to meet the KPIs' target values.

The time-based criterion helps business analysts in defining indicators, through questions such as: which is the most important indicators? Is it better to have an indicator for average, min or max process duration? So, after setting such an indicator under time-based criterion, we change this indicator from the average to the maximum process duration. Also, we add three additional indicators related to resource utilization, e.g., the number of personnel assigned to the pre-selection activity, which has a great influence on other indicators to complete in time. The human resources assigned in the first two phases in "Master's committee pool" is the highest rated indicator, because this indicator is more time-sensitive than the others. This importance is justified by the fact that any resource utilization or waste during the process execution has a direct impact on business process time cycle. Then, if we manage and respect the limited time-span of the first four activities for completion, it will have a great influence on the time completion of the other activities, and as a consequence, an influence on the process duration. Having recorded all responses, AHP synthesizes the priorities of alternatives with respect to each SMART criterion. The result is given in Fig.4.

2-Pairwise comparison and revision of qualitative KPI under each criterion:

Now we move to the adoption of the AHP method and SMART criteria for qualitative indicators and we focus and describe some AHP steps as follows: Once we have SMART criteria ranked, we must check the first suggested questions (qualitative indicators) in order to come up with an action plan of how the Master's committee can improve the business process.

When setting KPI weight under "Relevant" criterion, we try to answer a question such as: does this indicator help to better understand business process situation?. In the realistic criterion, the Master's committee is interested in all indicators, related to the questions during the interview, which are aligned with master's degree plan and with the appropriate amount of time to respond to each question. In this way, these indicators are moderately more important than other qualitative indicators.

Min score retained from Preregistered candidates who has a fundamental license	,041
Min score retained from Preregistered candidates who has a Applied license	,041
Min score retained from Preregistered candidates who has a fundamental license from other institutes	,040
Max waiting time from pre-registration online activity to notify candidate activity	,039
Max waiting time from interview activity to notify candidate activity	,039
Max process duration	,039
Min score retained from accepted candidates (after interview) who has a fundamental license	,039
Min score retained from accepted candidates who has a Applied license	,039
Min score retained from accepted candidates who has a fundamental license from other institutes	,039
Number of personal assigned in the calculation score activity	,038
Number of personal assigned in the pre-selection activity	,037
Number of jury during the interview	,036
Number of accepted candidate before administrative registration	,036
Number of candidates on the waiting list	,036
Number of newly registered candidates in first level SIAD master degree	,036
Number of candidates who repeat M1	,036
Number of registered candidates in second level SIAD master degree	,036
Number of abundant Candidates	,036
Number of graduated candidates	,036
Number of all Pre-registred candidates	,035
Number of all Preselected candidate who has a fundamental license	,035
Number of all Preselected candidate who has a applied license	,035
Number of all Preselected candidate who has a fundamental license from other institutes	,035
Number of all interviewed candidates	,035
Number of final selected candidate who has a fundamental license	,034
Number of final selected candidate who has a applied license	,034
Number of final selected candidate who has a fundamental license from other institutes	,034

Fig. 4. SMART KPIs obtained by the AHP method

To compare indicators under "Specific" criterion, we check whether the question is clear for the candidate and whether it adds insight and understanding for the master's committee. After comparing all qualitative indicators, we conclude that they are equally important.
All qualitative indicators are equally important under "Time-Based" criterion because the satisfaction evaluation was carried out at the same time frame. For the comparison under "Measurable" criterion, some qualitative indicators can be measured by another indicator. For example the time of response for each question, the installation during the interview (e.g. number of the available desks, chair, opened windows). All qualitative indicators are equally important under "Attainable" criterion because the master's committee should take into account the satisfaction of the candidate to improve the quality of the offered service.
In the synthesis phase, AHP combines the criteria weights and the KPIs scores, thus determining a global score for each KPI, and a consequent ranking. The global score for a given KPI is a weighted sum of the scores obtained with respect to all considered criteria.

7 Discussion

After studying several research papers, in this section, we try to discuss the differences between our proposed approach and other related works summarized below.
Ensuring that the predefined indicators are SMART is partially dealt with in the works of Del-Rio-Ortega (Resinaset al, 2014) and Resinas et al. (Maté et al, 2017). In our work, this is obtained when applying the AHP methodology by evaluating KPIs alternatives with respect to

previously determined criteria. Therefore, it is necessary to consider all relevant criteria and make judgments according to professional experience so that results give adequate answers.
Quantitative and qualitative consideration for the evaluation of performance is covered by the majority of works such as those of Peral et al. (Suryadi, 2007), Del-Rio-Ortega (Resinaset al, 2014), Resinas et al. (Maté et al, 2017), etc. But they only cover one side (quantitative or qualitative indicators) and maybe this is justified by the context of their research. However, very often, KPIs have been defined without an understanding of their purpose and the whole process. For this reason, managers, process measurement specialists, or business process analysts, as in our case study, need to ensure that everyone involved in the improvement of the business process is aware of goals. In our work, we take into consideration the various points of view of the people participating in the judgmental process (through the definition of quantitative and qualitative indicators).
Methodological support for improving the definition of existing KPIs is partially solved by Resinas et al. (Maté et al, 2017) and Shahin et al. (Shahin & Mahbod, 2007). In our work, we aim to improve the definition of KPIs by proposing a new approach in which we guarantee that all indicators are specific and measurable and just the other criteria make the difference in calculating priorities. In summary, the aim when using the AHP method is to find the most relevant KPIs and to guarantee that the ranking criteria and alternatives are up to date, as a consequence the prioritization acts as an enabler rather than the ultimate goal.
Methodological support for discovering KPIs is not considered in the existing work. In our work, to be more effective, after reviewing the synthesis we can discover another indicator not mentioned before. This step helps us to ensure that our KPIs are sufficient regarding our goal and to check our KPI requirements for ambiguities or completeness. Also in defining the first list of KPIs, the discussion and collaboration between different stakeholders in the business process concerning the definition of KPIs form an innovative way to discover another indicator (e.g. the open questions in the qualitative inquiry).
Now regarding the limitations of the 3 step proposed approach, we can mention that the proposed approach first requires having good expertise in order to be able to define the starting list of KPIs. However, our target users may have limited knowledge and expertise and they are consequently unable to start using our approach. Second, after the decision-maker analyzes data and KPI synthesis, s/he will be able to identify possible improvements or decide to reengineer the² BP in question. However not all improvement plans can really be applied.
The main limitations in this case study are that on the one hand, the improvement in the BP may not have a direct impact on current university years but in the following years. For this reason, we must get all possible KPI values from as many university years as possible. On the other hand, the qualitative aspect in the candidates' selection process cannot be fully exploited because satisfaction statistics report had not been generated before. As a consequence, these data are unavailable and the global qualitative indicator is discarded. In this case study, we also discard basic indicators related to each candidate process instance because the decision-maker gives more importance only to global indicators.

8 Conclusion

The main goal of this paper is to select and define a coherent set of SMART KPIs that has a considerable impact on the improvement of business processes and on the performance of the organization. With an increasing variance of many indicators and many conflicting criteria, the decision on appropriate KPIs becomes more and more critical. We developed a new approach to

develop a set of KPIs based on the integration of the Analytic Hierarchy Process (AHP) method and SMART criteria. We believe that successful KPI management is a continuous cycle involving defining KPIs, monitoring KPIs and improving KPIs.
As future work we can consider others multi criteria methods and comparing them in order to select the one that best fits our goals.

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