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Hybrid Approaches of Verbal Decision Analysis in the Selection of Project Management Approaches

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Abstract

Decision support methods aim at assisting in the decision-making process by simplifying the analysis of the problem and justifying the choice of a particular potential action. Recent researches have shown that the hybridization of methods is able to overcome limitations presented by the methods when applied separately: the classification of alternatives before submitting them to an ordination methodology would be an effective way of filtering the set to be ordered. Specific Practices of Capability Maturity Model Integration were analyzed through a decision making model, assisted by the methods SAC and ZAPROS III-*i*. The results will be compared to previous studies.

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Keywords: Hybrid Methodologies; Verbal Decision Analysis; SAC; ZAPROS III-*i*; Project Management; Capability Maturity Model Integration; Decision Support Systems

1. Introduction

Decision making is a process that is present throughout a person's life. Some decisions are simple, but others require a further analysis since a considerable number of factors are involved. The impact of each decision is analyzed mainly with respect of two points of view, being one in favor of it and one against it. Thus, the basis for decision-making is the exposure of the pros and cons and the analysis of them as a whole. This analysis of pros and cons from different points of view is called "Multiple Criteria Decision Analysis" (MCDA). The analysis of these scenarios helps to generate knowledge about the decision context, and, consequently, increases the confidence of those who make decisions [1, 2].

Multiple criteria decision support methods have gained prominence in various scenarios, and decision support methods play a main role on assisting professionals either from the business, by supporting management decisions (as in [3, 4, 5, 6, 7]), or from the health area, by aiding on early diagnosis of diseases as Alzheimer, Diabetes, psychological disorders, such as psychotic, mood or anxiety disorders, antisocial personality, etc., and Attention Deficit - Hyperactivity Disorder (ADHD) [8, 9, 10].

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The Verbal Decision Analysis (VDA) is a methodological approach of MCDA that supports the problems resolution in a verbal way. When applying VDA methods, one is not required to assign numeric degrees of preferences to a criteria value in relation to another. This way, the procedure that it applies to determine the preferences of a decision maker on a given context is psychologically valid, respecting the limitations of the human information processing system [11]. Also, according to [12], the procedures that acquire verbal preferences of a decision maker are more stable and consistent.

On the other hand, the amount of criteria and values of criteria that these approaches support is limited and there is nowadays a constant need for applying these methodologies to real world problems, since they are clearer and more understandable from the decision maker's point of view.

This leads us to the necessity of creating more robust procedures to be applied to large scale problems, reducing the notable impact on the methods' complexity caused by the consideration of a great amount of aspects of a determined problem.

The latest works in the area have shown that the hybridization of methods is able to overcome the limitation presented by the methods when they are applied separately. Several papers published on the area, in particular, involving Verbal Decision Analysis methods, were structured on the assumption that the classification of alternatives before submitting them to an ordination methodology would be effective and the complexity of the ordering method would not be considered an impactful factor. The results of these researches are presented in [6, 7, 8, 10, 13, 14, 15, 16, 17, 18], among others.

Considering previous studies on Verbal Decision Analysis methods, it was observed that their structures are very similar. This pattern can be attributed to the fact that the origin of the methods was based on the three main methods proposed on [19], ZAPROS, ORCLASS and PACOM.

With the aim to evaluate the application of a hybrid approach involving the methods SAC [20] and ZAPROS III-*i* [2] we will use the decision making model approached in a previous study [7], which applied the methods ORCLASS method [19], through the ORCLASSWEB tool [21], and ZAPROS III-*i*. This way, we intend to evaluate the effectiveness of the SAC method when applied to the same problem and also reinforce that classification methodologies of the Verbal Decision Analysis area can be integrated to ordering methodologies of this same area, by providing the ordering method the same expected input, which is the output of the classification methodologies.

In this context, we introduce the problem of choosing practices of Project Management to be implanted on a company. Project Management is a field of Software Development and Information Technology applied by organizations to coordinate and monitor projects. Although all the standardization and consolidated concepts determined by Project Management Institute (PMI), software development organizations still face large difficulties to implant functional and effective practices of Project Management.

Certain institutes emerged providing several approaches to be adopted in order to help Software Development Enterprises to produce a high quality project management in accordance to PMI, such as the Capability Maturity Model Integration (CMMI). The CMMI is a model that focuses on the definition of processes in several fields. It defines activities and approaches to be implanted by a Software Development Enterprise, presenting SCRUM approaches in order to attend to the process area. However, implanting every Specific Practice (SP) of the CMMI in a company can be costly and time consuming, which represents an obstacle faced by the organizations.

The Specific Practices (SP) of CMMI level 2 can be described and evaluated qualitatively. Therefore, the motivation to provide a decision making result in processes approaches emerged, according to a qualitative point of view.

In the problem in question, the application of methods SAC and ZAPROS III-*i* came to acceptance by the decision maker, which meant that the issues that were being presented to the decision maker made sense to him, and he had confidence in answering them. Beyond this point, extolled the need to assess the acceptance of the data, its properties used by the method, and the results supported the decision process. Secondary issues such as the existence of tools were also observed, as those would allow greater integration with the problem addressed. Still in the view of the authors, they agree with [22], which stressed that the methodology for multicriteria decision has several methods that can be applied in various problems.

The paper is structured as follows: we start presenting the SAC and ZAPROS III-*i* methods, and flow-charts will be presented for better comprehension.

For the hybrid model resolution, we will apply the SAC method to classify the CMMI level 2 Specific Practices (SP), which will be the alternatives of this first part of the problem, into ordered decision groups. The division will allow the identification of which SPs should be considered by the organization that aims to implant part of this project management framework.

After the classification is completed, we will apply the ordering method ZAPROS III-*i*, through the Aranaú tool. This will provide an ordering of the approaches and activities within every SP that was previously classified into the group that should be considered by the organizations. This ranking will be valuable for the organizations to choose the practices that they would like to implant. At the end, we present the computational results obtained in order to solve the problem described.

At least, the classification method SAC will be compared to the ORCLASS one considering the results obtained in this paper and in previous studies.

2. The Subset Alternatives Classification Method (SAC)

The SAC (Subset Alternatives Classification) method [20] is a method for ordinal classification of a relatively small set of alternatives that need to be classified only once [23]. The method aims at presenting the minimum number of questions to the decision maker in order to reduce the time spent in the preferences elicitation task. To do so, it has a determined improvement, when compared to ORCLASS system, by using a variance to calculate the most informative vector based on its likeliness be assigned to a class.

Fig. 1 presents a flowchart with steps to apply the SAC method.

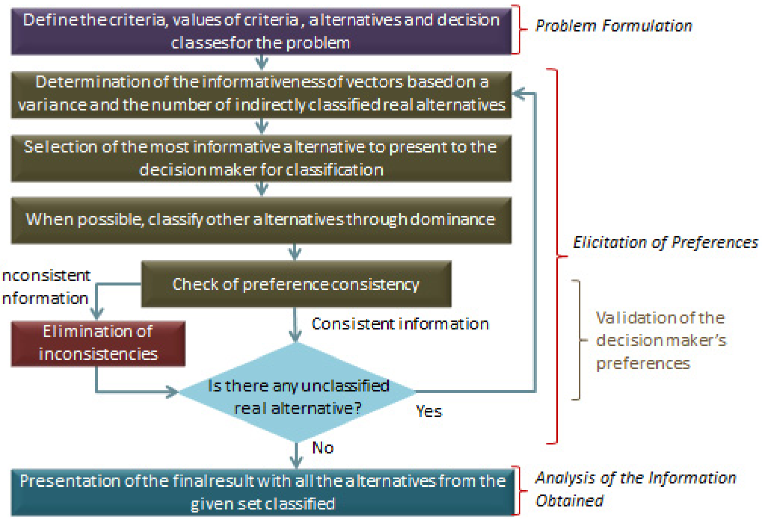

Fig. 1. Process applied to classify a set of real alternatives in the SAC method

The method's application is very similar to the ORCLASS [19] one. The difference is that it only considers the real alternatives when calculating the informativeness of vectors to be presented to the decision maker for classification, thus, making the process less complex by not involving the classification of the Cartesian product of criteria values.

In order to calculate the most informative alternative vector to be presented to a decision maker, the research presented on [20] uses the following definition: g_{il} - represents the number of vectors from the real alternatives that are not yet assigned to classes and that can be indirectly classified when an alternative y_i is classified by the decision maker into class C_l.

As one cannot know in advance the class that this vector will be assigned to, it is suggested that an index to calculate the likeliness of this vector be assigned to class g_{il} is introduced when evaluating g_{il}. Thus, being p_{il} an index to define the likeliness of y_i to be assigned to class C_l, it is required to maximize the amount of information generated ϕ_i, which is defined by:

$$\phi_i = \sum_{l=1}^{l=L} p_{il} g_{il} \quad (1)$$

There are many ways to calculate the index p_{il}. Some papers propose that this index is calculated based on the distance that alternative y_i is to the center of class C_l.

Also, according to [23], the SAC method works with "relative informativeness" of a vector by considering a variance, which depends on the number of classes and criteria defined, in the number of indirectly classified alternatives. This way, considering g_{il} as a random parameter G_i with an expected value MG_i (φ_i), the representation of the variation of G_i near MG_i, where DG_i is the variance of G_i, is given by [20]:

$$\sigma_i = \sqrt{DG_i} = \sqrt{M(G_i - MG_i)^2} \quad (2)$$

Also, according to [20], a large value of φ_i causes large deviations, so a relative and not an absolute deviation should be considered. Thus, being v is the relative importance of variance ($v \geq 0$), and $\frac{\phi_i}{\varphi_i}$ represents the relative deviation of g_{il} from an average value, the expected amount of information can be given as follows [20]:

$$\psi_i = \frac{\varphi_i}{1 + v\frac{\phi_i}{\varphi_i}} \quad (3)$$

Based on the results exposed on [20], it is given that the recommended values for this variance are between 2.2 and 3.5, and once this number is equal to zero, the informativeness of the alternatives vector is calculated as in ORCLASS method [23].

More information regarding the SAC method can be found in [20].

3. The ZAPROS III-*i* Method

A method structured mainly on the ZAPROS method [11] is proposed on [2, 24, 25]. According to [26], "One of the most important features of ZAPROS methods is the use of psychologically grounded procedures for identifying the preferences. This method evaluates personal abilities and limitations of human information processing system. The disadvantages of the method also include the limited amount of attributes and difficulties in using quantitative criteria".

The method presents three main stages: Problem Formulation, Elicitation of Preferences and Comparison of Alternatives, as proposed on the original version of the ZAPROS method. An overview of the approach is presented bellow. Figure 2 presents the structure of the ZAPROS III method.

The Preferences Elicitation process can be started once the problem formulation one is completed. At this stage, the scale of preferences for quality variations (Joint Scale of Quality Variations - JSQV) is constructed. The elicitation of preferences follows the structure proposed in [2]. For this stage, the decision maker needs to inform his/her preferences for the quality variations of each criteria. The questions to Quality Variations (QV) belonging to just one criteria will be made as follows: on the assumption that a criterion A has $X_A = \{A1, A2, A3\}$, the decision maker will be asked about his/her preferences between the QV $a_1 - a_2$, $a_1 - a_3$ and $a_2 - a_3$. Thus, there is a maximum of three questions to a criterion with three values ($n_q = 3$). In the worst case, the number of questions presented will be the same as the amount of QVs for a criteria, which is given by $\binom{n_q}{2}$.

The questions are formulated in a different way on the elicitation of preferences for two criteria, because difficulties in understanding and delay in the decision maker's answers were noticed when QVs of different criteria were exposed. This way, the question will be made by dividing the QV into two items. For example, for a set of criteria K = {A, B, C}, where $n_q = 3$ and $X_q = q_1, q_2, q_3$, considering the pair of criteria A, B and the QV a_1 and b_1, the decision maker should analyze which imaginary alternative would be preferable: A1B2C1 or A2B1C1. However, this answer must be the same to alternatives A1B2C3 and A2B1C3. If the decision maker answers that the first option is better, then b_1 is preferable to a_1, because it is preferable to have B2 in the alternative instead of A2. The decision maker is asked to compare the QVs considering a pair of criteria only, and at the end of this

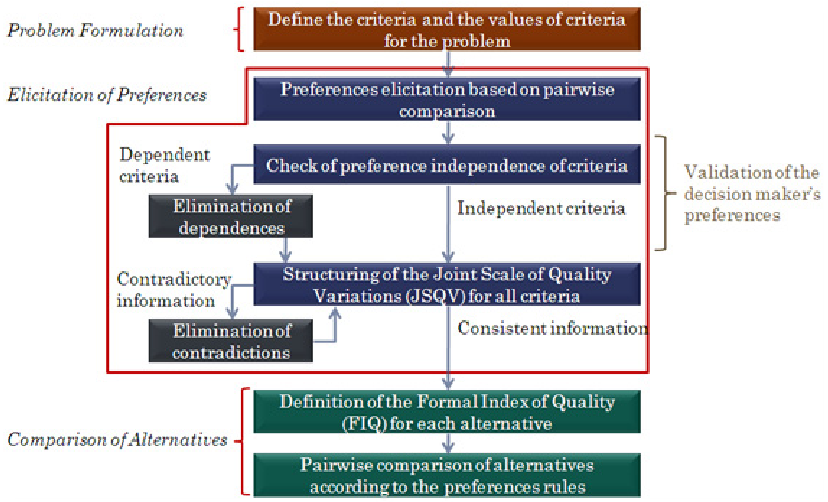

Fig. 2. Procedure to apply the ZAPROS III method.

stage, we have all the preferences scales for the pairs of criteria. Therefore, the number of scales at this point will be $\binom{N}{2}$, where N is the number of criteria for the problem.

The process to obtain the JSQV for all criteria is given by the sequential removal of the non-dominated QV from all scales.

The alternatives comparison process is carried out after the decision rule is obtained. Each alternative has a function of quality - V(y) [11], depending on the evaluations of the criteria that it represents. In [27], it is proposed that the vectors of ranks of the criteria values, which represent the function of quality, are rearranged in an ascending order. Then, the values will be compared to the corresponding position of another alternative's vector of values based on Pareto's dominance rule. Meanwhile, this procedure was modified for implementation since it was originally proposed for scales of preferences of criteria values, not for quality variation scales.

In cases where the incomparability of real alternatives will not allow the presentation of a complete result, one can evaluate all possible alternatives to the problem in order to rank the real alternatives indirectly. The possible alternatives should be rearranged in an ascending order according to their Formal Index of Quality (FIQ) and only the significant part will be selected for the comparison process. After that, the ranks obtained will be passed on to the corresponding real alternatives.

In order to facilitate the decision process and perform it consistently, observing its complexity and with the aim of making it accessible, a tool was implemented in Java and it is presented by the following sequence of actions:

- Criteria Definition: The definition of the criteria presented by the problem;

- Preferences Elicitation: Occurring in two stages: the elicitation of preferences for quality variation on the same criteria and the elicitation of preferences between pairs of criteria;

- Alternatives Definition: The alternatives can be defined only after the construction of the scale of preferences;

- Alternatives Classification: After the problem formulation, the user can verify the solution obtained to the problem. The result is presented to the decision maker so that it can be evaluated. The comparison based on all possible alternatives for the problem is possible, but it should be performed only when it is necessary for the problem resolution (for being an elevated cost solution).

The Aranaú Tool [2] will be used on this study for the application of the ZAPROS III-*i* method.

More information about the ZAPROS III-*i* method is available in [2].

4. The Hybrid Model in Verbal Decision Analysis for the Problem

The use of hybrid methods plays an important role on the decision making scenario. The combination of classification and ordering tasks has come into play as a way of diminishing the complexity of the problem that needs to have its alternatives ranked. Several applications have already approached the hybridization of methods in Verbal Decision Analysis (VDA) and have shown stable and consistent outputs.

This way, in order to assist on selecting the best practices, and to compare the effectiveness of the SAC method to the ORCLASS one, a hybrid model using Verbal Decision Analysis was structured as follows. First, the classification method SAC [20] will be applied in order to classify the SPs of CMMI level 2 into two groups. On this model, the list of Specific Practices will be taken as the alternatives of the problem, since we intend to classify them into groups.

Similarly to the ORCLASS application [7], the first group will be composed by the SPs which are the most relevant ones to be used by a company that cannot implant the model as a whole. Then, this group will be used as the entry of the ordering method - the ZAPROS III-*i*. The second group will contain the remaining Specific Practices, and these will not be submitted to the ordering method.

In the study presented on [21], a set of criteria was defined together with an experienced professional, through the analysis of the CMMI model and by determining which characteristics should be considered on the analysis. Each SP is composed by activities and/or approaches, and these will be taken as the alternatives to the ordering method. This way, we intent to rank every activity and approach for each SP that is classified into the first group. For this stage, we also have analyzed the SPs and their activities, and sets of criteria were defined in order to evaluate them.

4.1. Step 1: SAC Method - Classification

This step is intended to identify which Specific Practice from Project Planning and Monitoring and Control Planning Process Areas of CMMI should be implanted by determined Software Development Companies and projects. Notice that the SPs to be analyzed are practices from CMMI level 2, which have adherence to SCRUM approaches in order to attend the process area.

Table 1 presents the list of criteria and criteria values used to evaluate the practices. The criteria values are described from the naturally most preferable to the less preferable one.

Table 1. Criteria and criteria values to be used on the SAC method

Criteria	Values of Criteria
A: Interference Level on Deadline Accomplishment	A1. Interferes totally positively A2. Interferes partially positively A3. Does not interfere
B: Interference Level on Product Quality	B1. Interferes totally positively B2. Interferes partially positively B3. Does not interfere
C: Interference Level on Team Motivation	C1. Interferes totally positively C2. Interferes partially positively C3. Does not interfere

The alternatives used at the first part of the hybrid model are Specific Practices from Process Area "Project Planning". Through the analysis of each alternative together with the decision maker, an experienced professional in processes implantation, it was possible to represent the alternatives in criterion values. The alternatives defined to the problem as well as their representation on criterion values are presented in Table 2.

The classification of the alternatives was made considering the real alternatives to the problem, and the information index of the alternatives was calculated after each response of the decision maker considering the likeliness of each of them to be assigned to a determined class. For this application, we used a variance of 3 to calculate this likeliness, based on the research presented on [19].

Therefore, the final classification of the alternatives is given by:

Table 2. Alternatives described as criteria values to be classified by the SAC method application

ID	Alternatives	Representation
SP1	SP 1.1 Estimate the Scope of the Project	A1 B2 C3
SP2	SP 1.3 Define Project Lifecycle	A2 B2 C3
SP3	SP 1.4 Determine Estimates of Effort and Cost	A1 B1 C2
SP4	SP 2.1 Establish the Budget and Schedule	A1 B1 C2
SP5	SP 2.2 Identify Project Risks	A1 B1 C3
SP6	SP 2.4 Plan for Project Resources	A2 B1 C2
SP7	SP 2.5 Plan for Needed knowledge and Skills	A2 B2 C2
SP8	SP 2.6 Plan Stakeholder Involvement	A1 B2 C2
SP9	SP 2.7 Establish the Project Plan	A1 B2 C3
SP10	SP 3.1 Review Plans That Affect the Project	A1 B1 C3
SP11	SP 3.2 Reconcile Work and Resource Levels	A1 B1 C3
SP12	SP 3.3 Obtain Plan Commitment	A2 B2 C1

- Class I: SP3, SP4, SP5, SP6, SP8, SP10, SP11 and SP12;
- Class II: SP1, SP2, SP7 and SP9.

After this step was completed, we were able to compare it to the the previous results obtained by the ORCLASS method [7]. In this scenario, the same classification was obtained, however, since the SAC method classification considers only the real alternatives of the problem, the process did not demand so much time of the decision maker, presenting a total of 6 questions to complete the classification task against 13 questions presented on the ORCLASS method's application.

4.2. *Step 2: ZAPROS III*-i *Method - Ordering*

For the second part of the application, only the SPs that were classified into Class I according to the SAC method's application will be considered. These alternatives are the Specific Practices of CMMI level 2, Process Area Project Planning. For each SP, the activities and approaches which compose them were identified. These will be taken as the alternatives for the ordering method. This way, the ordering task in order to rank the activities and approaches within the practices will be performed for every SPs that belong to Class I.

Considering that this part of the application involves the evaluation of several multicriteria models (one for each selected SP), we will not be able to present the application of the ZAPROS III-*i* method for each Specific Practice. In this scenario, we will present the model used to evaluate SP3 - 1.4 Determine Estimates of Effort and Cost. The complete model, including the criteria and criteria values used for evaluating each SP can be found in [7, 21].

Due to the complexity of this part of the application, the ZAPROS III-*i* method was applied through the Aranaú Tool, in order to facilitate the process (since the ordering task was performed several times) and to make the application more reliable.

4.2.1. *The ZAPROS III*-i *Method Application - Specific Practice 1.4*

The activities implanted by companies in order to attend the Specific Practice SP 1.4 are presented on Table 3. These will be the alternatives for the ordering method.

Table 3. Approaches of Specific Practice 1.4

Alternative	Description
A1	Story Points + Planning Poker
A2	Use case Points
A3	Estimation by specialist
A4	Function Points Analysis

Similarly to the SAC method's application, the criteria and values of criteria will need to be defined in order to evaluate the approaches presented. The criteria established in Table 4 were defined in the Aranaú Tool via "Criteria Definition" interface.

Table 4. Criteria and criteria values to evaluate SP 1.4

Criteria	Values of Criteria
A: Predictability of Scope Estimation	A1. Provides high predictability A2. Provides medium/moderate predictability A3. Provides low predictability
B: Effort to estimate	B1. Causes the less effort possible to estimate B2. Causes moderate effort to estimate B3. Causes high and impacting effort to estimate
C: Client's facility in scope estimation understanding	C1. Easy scope estimation understanding C2. Moderate scope estimation understanding C3. Hard scope estimation understanding

Following the procedure defined on the ZAPROS III-*i* method, the process of elicitation of preferences initiates and the preferences will be identified in accordance to the decision maker's answers. The process of elicitation of preferences is performed in the "Elicitation of Preferences" interface of the Aranaú Tool.

After having the decision maker's preferences, the tool will present a screen - "Alternatives Definition", and request that the alternatives are entered and their values of criteria for every criteria defined (Table 4) are specified. The alternatives for this problem are the approaches listed in Table 3.

Consolidating the results from the hybrid application by the analysis of all the results obtained when submitting the models of the previous sections to the Aranaú tool, it is possible to identify the most preferable approaches within each selected Specific Practices from Process Area Project Planning of CMMI level 2 that should be implanted. This way, the most indicated approaches to be implanted on a company in order to assist in their projects are presented in Table 5.

According to the results, the preferable alternative is given by "Story Points + Planning Poker". The following sections will present the alternatives and criteria tables for each practice of Class I.

Table 5. Final Result: Specific Practices and Approaches

Specific Practice	Preferable Approaches
1.4	Story Points + Planning Poker
2.1	Schedule in spreadsheet + budget
2.2	Risk Management Plan
2.4	WBS extension
2.6	Communication Plan, *and* Stakeholders definition during the project's conduction
3.1	Review Registration in minutes
3.2	Reviewed Project Plan
3.3	Sprint Planning 2, *and* Start up/Kick off meeting + minutes

5. Conclusions and Future Works

Considering the advances that hybrid approaches have obtained on handling large scale problems, it is clear that the combination of classification and ordering tasks plays an important role on diminishing the complexity of the problem that needs to have its alternatives ranked. In such cases, the classification task works as a filter, and only the relevant parts of the problem will be analyzed by the ordering method. This task is not limited to the Multiple Criteria Decision Analysis field, and studies involving Machine Learning methods have also been combined to ordering methodologies.

With this pre-selection, one can observe that the most relevant values of aspects being considered will be selected, which might allow the elimination of criteria values that are not relevant to the ranking approach. By not relevant criteria values, we mean the ones that composed alternatives that were not selected as suitable from the decision maker's point of view, and they do not characterize any alternative present in the selected classes. Thus, one can observe that the most relevant values of criteria were selected to be contemplated in the ranking method. This approach results in a more robust methodology than the methods applied individually, and they enable the resolution of problems that were before considered of large scale from a single method's point of view.

Also it is important to state that classifying the alternatives into groups, does not mean that a determined group will not have its alternatives ranked: all the classes can be submitted to the ranking method separately, each one representing a different domain for the method's application.

This research, thus, intended to evaluate the application of a hybrid approach involving the methods SAC [20] and ZAPROS III-*i* [2] using a decision making model approached in a previous study [7], on which the methods ORCLASS [19], through the ORCLASSWEB tool [21], and ZAPROS III-*i* were applied. This way, it was possible to evaluate the effectiveness of the SAC method when applied to the same problem and also reinforce that classification methodologies of the Verbal Decision Analysis area can be integrated to ordering methodologies of this same area, by providing the ordering method the same expected input, which is the output of the classification methodologies, since the multicriteria problem remained the same for both applications.

In this context, we introduced the problem of choosing practices of Project Management to be implanted on a company. Several approaches can be adopted in order to help Software Development Enterprises to produce a high quality project management in accordance to PMI, such as the Capability Maturity Model Integration (CMMI). However, implanting every Specific Practice (SP) of the CMMI in a company can be costly and time consuming, which represents an obstacle faced by the organizations. Since the Specific Practices (SP) of CMMI level 2 can be described and evaluated qualitatively, the motivation to provide a decision making result based on Verbal Decision Analysis methods emerged.

After the classification step was completed, we were able to compare it to the the previous results obtained with the ORCLASS method [7]. In this scenario, the same classification was obtained, however, since the SAC method classification considers only the real alternatives of the problem, the process did not demand so much time of the decision maker, presenting a total of 6 questions to complete the classification task against 13 questions presented on the ORCLASS method's application. Also, the SAC method only considered the 8 distinct real alternatives to be classified, while the ORCLASS one tries to classify all the possible alternatives for the problem, in order to structure a classification rule, in this case, 25 alternatives (excluding the two reference situations). The classification rule might be helpful depending on the kind of problem being approached, for example, a problem where the criteria or criteria values might change constantly. Since this was not applicable to the problem being approached, the SAC method presented itself more effective on the classification task.

Another contribution of this work is the mix of different areas, Software Engineering and Operational Research (multi-criteria), for solving real and recurrent problems of decision making faced by several software development companies, and the possibility of applying Verbal Decision Analysis in real life problems to aid companies that cannot implant CMMI as a whole.

As future works, we intend to structure a multicriteria model focused on social problems, for example, the early diagnosis of diseases, which has been the subject of previous researches, and apply a hybrid methodology based on different VDA methods. It is also intended to compare the results obtained and the knowledge-expert's (decision maker) output regarding the time consumed and difficulty on answering the required questions in the classification and ranking tasks.

Considering the advances that hybrid approaches have obtained on handling large scale problems, a further study of other VDA methods will also be performed, in order to propose other hybrid algorithms based on the characteristics of each approach.

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