PRIORITIZATION OF STUDENT PROJECT PROPOSALS – A MULTICRITERIA APPROACH

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Abstract

Due to everyday burst of technological developments and their application in the field of project management, there is a lasting need for improvement in student teaching and assessment processes. Such place where engineering students can be challenged both creatively and by knowledge in complex project environment can be found in the graduate study programme under the course of Project Management at the Faculty of Civil Engineering in Rijeka. As one of the course objectives is active work on actual project proposals, students are divided into supervised teams. Each team is responsible for the development of one project scenario for the Project Delta in the city of Rijeka, and is evaluated as the best project proposal among defined project teams and their proposals. Prioritization of project proposals deals with complex decision making. It is characterized by lots of participants, multidisciplinarity, huge quantities of information, limited budget, conflict goals, and criteria. In order to cope with such complexity and to help professors during decision making processes, this paper proposes the use of multi-criteria methods for solving priority setting problem. The starting point in this methodology is goal analysis and development of adequate criteria set. Evaluation of criteria importance is based on a set of experts' opinions processed by AHP method, while all data processing is done by PROMETHEE multi-criteria methods. The end result is a priority list of student project proposals. By presented methodology specialized software is introduced into education process of construction management, thus innovating curriculum and assessment of the course.

Key words

Decision support, Multi-criteria methods, Priority, Project management

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1 INTRODUCTION

Construction project management is a difficult task when one takes into account the complexity, uncertainties, and large number of activities involved. The increasing complexity and uncertainty of construction projects has led to many significant losses for the construction industry. Problems related to the management of projects, specifically prioritization problems, can be found in all stages of projects' life cycles, mostly as the result of inadequate decision making. In order to cope with such complexity, the use of multi-criteria decision analysis (MCDA) is proposed.

Faculty environment, for sure, is a safe environment for students to learn and apply acquired knowledge. Their lack of business and field experience can be overcame by involving projects' knowledge from business sector into academic teaching and *vice versa*. At the Faculty of Civil Engineering in Rijeka students of university graduate study program in civil engineering have an opportunity to learn and evolve in the area of project management within the scope of Project Management course. In order to simulate the real environment of infrastructure projects (Project Delta in the city of Rijeka), students are grouped into project teams' thus engaging active work on actual project proposals. That way, students can express their accumulated knowledge and, at the same time, see themselves how they manage in project environment.

In this paper, we propose the use of multi-criteria decision analysis enriched by involvement of the objectives of different interest groups or stakeholders for solving priority setting problem i.e. for the evaluation of student project proposals. It has been structured into five sections: Section 1 contextualizes project management with emphasis on decision making and the university education of project management, and also defines the objective of the paper; Section 2 presents the literature review of group decision making and use of PROMETHEE multi-criteria methods; Section 3 shows the structuring of the typical problem of project prioritization–selection of the best project solution; Section 4 shows the results of the study followed by discussion; finally, in Section 5, the conclusions of the study are presented.

2 LITERATURE REVIEW

According to the PMI [1], project management involves nine managerial fields: time, cost, human resources, quality, procurement, scope, communication, integration, and risk management. All of them must be managed and integrated *de facto*, and it is clear that decisions drive projects. Decisions are made based on assumptions which are necessary because the outcome is in the future, and therefore uncertain. So, decision making can be seen as critical success factor.

Because of the increasing complexity of the socio-economic environment nowadays, many decision-making processes in the real world take place in group settings. Wu and Xu [6] proposed a consistency and consensus based support model to support the consensus reaching process in group decision making (GDM) with multiplicative preference relations. The concept of stakeholders was introduced in the research field of strategic management [2].

Freeman [3] defines a stakeholder as an individual or a group of individuals who can influence the objectives of an organization or can be influenced themselves by these objectives. As this definition is very broad better definition is incorporated by Grimble and Wellard [4]: "Stakeholders are any group of people, organized or not organized, who share a common interest or stake in a particular issue or system". Marcharis et al. [5] deleted "common interest" from previous definition. That way definition leaves the door open for any person or group who, by merely intellectual curiosity, would like to be involved in the decision making process.

For prioritization purposes different methods were used for multi-criteria decision making. Mostly the AHP method [7] is used with different variations though the years. The other outranking method, PROMETHEE [8], is often used as well but it is important to see operational synergies in multi-criteria analysis between these two methods. Strengths and weaknesses of the PROMETHEE and AHP were discussed [9] and the recommendations are formulated to integrate AHP ideas into PROMETHEE especially as regards the design of the decision-making hierarchy (ordering of goals, sub-goals, dimensions, criteria, projects, etc.). Such synergy of methods is visible in different prioritization purposes like life-cycle management of urban infrastructure projects [10], problems of construction site selection [11], and sustainable real estate value management [12].

Multi-criteria decision analysis is often use in different university environment. Bana e Costa and Oliveira [13] proposed a MCDA model for faculty evaluation, while Wu et al. [14] used AHP for selecting the optimal assessment tools for use in students counselling. There is also a application of these methods in selecting scientific award winner [15].

3 METHODOLOGY

Considering the importance of multi-criteria methods in dealing with human reality, several approaches have been proposed. All of them replace the search for the optimal solution for those of greatest commitment. They are used to support people and organizations to make decisions. As said, we found AHP [7] and PROMETHE [8] appropriate for implementation in our prioritization model PRIMO (Fig.1) for the purpose of solving priority setting problem.

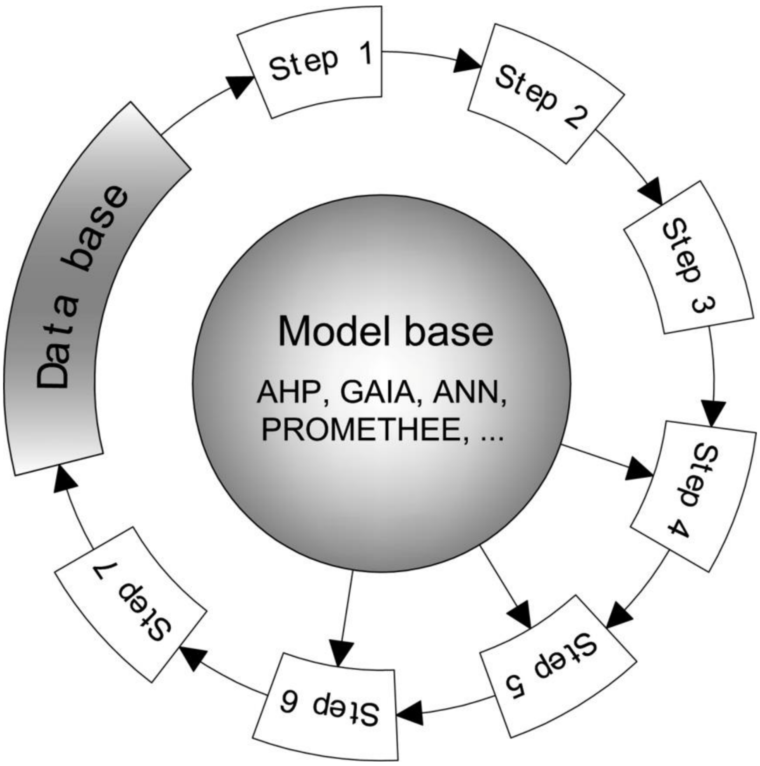

Fig. 1: Prioritization model PRIMO

Proposed prioritization model (PRIMO) consists of data base module, model base module, and seven procedure steps. Data base module is based on LMS online platform Mudri [16], course web-location, where all data are stored and collaboration between interested groups (faculty staff, students, and external experts i.e. project managers) is taking place. Although model base module consists of various models, for the purpose of prioritization of student project proposals the AHP [7] method as well as the PROMETHEE [8] multi-criteria methods were used.

Procedure starts with beginning of the course (step 1) with implementing data from data base module followed by presenting and assigning the project to students (step 2). In step 3 students are grouped into project teams and from this point further students' work as a team on a project proposal. Determination of goal, criteria and weights (step 4) is a crucial point in prioritization model because it is the place where model and interested groups (both professors and students) meet for the first time. Evaluation of criteria importance is based on a set of their opinions processed by AHP method. Goal analysis is followed by determination of alternatives (step 5) i.e. project proposals. Data processing is done by PROMETHEE multi-criteria methods (PROMETHEE I and PROMETHEE II) in step 6. The result of data processing is priority rank of all project proposals i.e. rank-list. Procedure finishes with selection of best project proposal (step 7), and recording back into data base.

The aim of the PRIMO is to help professors (i.e. decision makers) to make consistent decision about efficiency of several different student group (i.e. project teams) project proposals in form of the final rank-list.

3.1 Determination of goal, criteria and assigning weights

The procedure of establishing the hierarchical structure of goals begins by defining the main goal (GC), and then follows the forming of the group, that is the forming of the resource pool of experts (Fig. 2). From among them, experts of the first rank (E1R) are chosen and they generate goals of the first rank (C1R). After the first rank goals have been generated with the help of the first rank experts, the second rank experts (E2R) are chosen from the resource pool of experts and they generate goals of the second rank (C2R). In this way both the generation of goals and the hierarchical structure of goals itself have been established. It must be mentioned that experts of both first and second rank may be individuals, but they can also be expert groups whose task may be either to determine the value of only one group of goals [12], or to determine the value of all goals in the respective rank.

For PRIMO purposes experts of the first rank are professors of particular course, while the second rank experts are both professors and students (precisely student representatives as team leaders). In this way both professors and students are involved in establishing the hierarchical structure of goals.

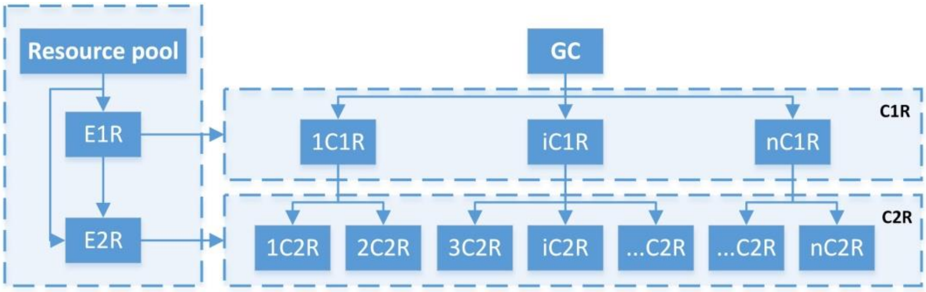

Fig. 2: Hierarchical goal structure [12]

Decomposition of the main goal leads over the objectives (i.e. sub-goals) to the criteria. In the moment when the goals on the particular level of decomposition become clear (when they can be precisely described) and measurable (when they can expressed both quantitatively and qualitatively), they become criteria. After all goals (C1R and C2R) have been defined, it is necessary to determine their importance. In Table 1 all identified goals, objectives (i.e. sub-goals), and criteria along with their description and weighting is presented.

Tab. 1: Hierarchy, code and description of goal, objectives, and criteria with assigned weight

Hierarchy level	Code	Goals, objectives, and criteria	Criteria description	Weight
0	G	Project team success	Project team success is based on evaluation of written paper as well as oral presentation.	1
1	O1	Evaluation of written paper	Evaluation of written paper is based on performance on criteria C1 to C4.	0.50
1	O2	Evaluation of oral presentation	Evaluation of oral presentation is based on performance on criteria C5 to C10.	0.50
2	C1	Organization and logic	Paper organization is clear, logical, mature, and thorough development of subtopics that support thesis with excellent transition between paragraphs. Thesis is clear, arguable, well developed, and a definitive statement.	0.125
2	C2	Clarity of text and figures	Paper is written in clear, logical, mature text and figures. Paper is concise with consistently proper grammar, spelling and paragraphing. Critical, relevant and consistent connections are made between evidence, subtopics, counterarguments, and thesis showing excellent analysis.	0.125
2	C3	Conclusion justified by results	Based on given results, emphasizes significance and implications of the study. Summary of topic, thesis and all subtopics are in proper order with concluding ideas that leave an impact on a reader.	0.15
2	C4	Significance and originality	Project proposal is exceptionally researched, extremely detailed and accurate with critical evidence from a wide variety of sources. Methods are appropriate and properly applied.	0.10
2	C5	Organization and logic	Presentation organization is clear, logical and mature.	0.075
2	C6	Visual aids, legibility, and clarity	Audio-visual aids (if used) are well-prepared and appropriate.	0.075
2	C7	Effective use of time	Topical sequence logical, appropriate time given to sections of the presentation, keeps within allotted time.	0.075
2	C8	General style, liveliness and stage presence	Presenter is familiar with content, statements are clear, voice modulations appropriate, and maintains eye contact.	0.075
2	C9	Effectiveness in answering questions	Presenter has good grasp of study and related areas, and responds effectively and clearly to questions.	0.10
2	C10	Comprehension and knowledge of subject area	Presenter showed adequate comprehension and knowledge of the subject area as well as presented project proposal.	0.10

Determining the importance of criteria, i.e. assigning weight to each of them is necessary, because not all criteria are equally important. The determining of the weight of a particular criterion is the task of the experts, and it depends on the level, or rank, where the criteria are located and where weights are assigned to them by experts of that particular rank. It may happen that some of the experts of the first rank (E1R) are at the same time experts of the second rank (E2R) as well. In such cases it is suggested that experts should be allowed to freely choose the scale for assigning of the amount of importance. Such freedom granted to the expert represents his disburdening in terms of the form of evaluation, and it gives him the comfort to assign importance to the set criteria as quality as possible. After the expert has completed the described procedure, the assigned amounts need to be normalized [12].

After defining the goals, setting the criteria, and weighting them, the projects can be ranked. We used PROMETHEE II for ranking student project proposals. This method outputs information as a rank-list of reviewed projects, providing the decision-maker (i.e. professors) with the basis to make a decision and grade the projects.

4 RESULTS & DISCUSSION

4.1 Setting-up the prioritization model

By analyzing the project proposals, we established parameters so we could partially compare the projects using each individual criterion. Table 2 shows all the parameters in a decision matrix. It also presents the internal limitations of the method, particularly the measurement units and the scoring method according to the given criteria. It also defines the direction of preference (minimum or maximum) and shows the preference function.

Tab. 2: Decision matrix and preferences

		Criteria									
		C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
Project teams	**PT 1**	8,00	g	8,25	m	a	vg	3,00	vh	4,25	g
	PT 2	7,00	a	7,00	m	b	g	2,00	h	4,00	a
	PT 3	8,00	g	8,50	vh	g	g	4,00	vh	5,00	a
	PT 4	8,00	g	9,50	vh	vg	vg	1,00	vh	5,00	vg
	PT 5	8,50	vg	8,50	h	g	g	0,00	h	4,50	g
	PT 6	9,00	vg	9,00	vh	vg	vg	0,00	vh	5,00	vg
	PT 7	8,00	vg	7,50	h	vg	vg	1,00	vh	5,00	vg
Preferences	**Unit**	1-10	5-point	1-10	impact	5-point	5-point	unit	impact	1-5	5-point
	Min/Max	max	max	max	max	max	max	min	max	max	max
	Preference function	V-shape	Usual	V-shape	Usual	Usual	Usual	V-shape	Usual	V-shape	V-shape

Both professors and students evaluate project leaders i.e. presenters during their project presentation. Presenters were evaluated solely by professors according to C1, C2, C3, C4, C5, C7, and C10. According to the rest of criteria, presenters were evaluated both by professors and other project leaders.

As previously discussed, we used PROMETHEE II, specifically Visual PROMETHEE software, for student project proposals ranking. This method requires, in addition to inputting the basic parameters and weighting the criteria in the decision matrix, choosing the type of criterion through which possible incoherence in the data set and preference functions can be corrected. It is necessary to form a complex preference relation to emphasize that this outranking relation is based on many criteria and that it is founded on generalizing those criteria.

Defining the preference indices generates a complex preference relation, shown by using a preference graph. The essence of this step is in the fact that the decision-maker must give priority to one of the two alternatives, i.e. actions (activities) in each of the criteria, based on the difference between the criteria values of the compared alternatives.

For criteria C1, C3, C7, C9, and C10, the decision-makers did not clearly see the possible areas of indifference between the possible activities; in other words, they considered the differences in the values of the solutions expressed through these criteria as very important. Thus, for these criteria we used the V-shape Preference Function, which well describes the attitudes of these decision-makers. For the remaining criteria C2, C4, C5, C6, and C8, we chose the Usual Preference Function because, for the decision-maker, all activities are indifferent as long as the differences between their values do not exceed the threshold of indifference. When these differences do exceeds this threshold, we can define a strict preference.

4.2 Results of the prioritization model

The PROMETHEE Diamond (Fig. 3) is an alternate display of the PROMETHEE I and PROMETHEE II rankings provided by Visual PROMETHEE software. It shows both rankings in one 2-dimensional representation i.e. each action is represented as a point in the (Phi+, Phi-) plane. The plane is angled 45° degrees so that the vertical dimension (green-red axis) corresponds to the Phi net flow.

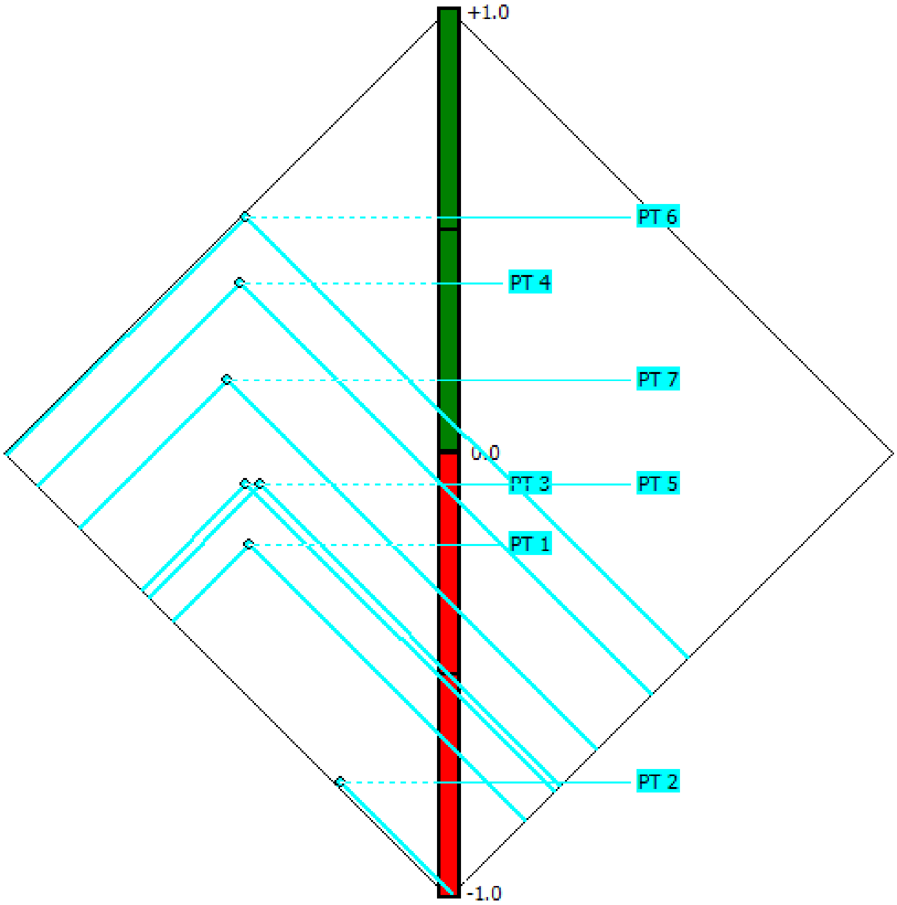

Fig. 3: PROMETHEE Diamond display of results

As shown in Fig. 3 each action is represented as a point in the (Phi+, Phi-) plane and a cone is drawn. When one cone is overlapping another it means that the action is preferred to the other one (e.g. PT 4 and PT 7, etc.), while in the case of intersecting cones (e.g. PT 3 and PT 5) correspond to incomparable actions (PROMETHEE I). As the vertical dimension corresponds to the Phi net flow complete ranking (PROMETHEE II) is visible. With such display one can visualize both PROMETHEE rankings at the same time.

Table 3 shows the results of numerically processing the inputted data. Using PROMETHEE II, we obtained the total Phi values of the flows; the method provided us with the sums of all input and output flows, i.e. with the domination ratios of particular pairs of actions.

Tab. 3: Result of complete ranking - PROMETHEE II

No.	Action	Phi	Phi+	Phi-
1	PT 6	0,5325	0,5375	0,0050
2	PT 4	0,3842	0,4581	0,0740
3	PT 7	0,1660	0,3342	0,1681
4	PT 3	-0,0681	0,2385	0,3067
5	PT 5	-0,0715	0,2529	0,3244
6	PT 1	-0,2044	0,1744	0,3787
7	PT 2	-0,7388	0,0094	0,7481

The result of PROMETHEE II is a rank-list of student project proposals. It is graphically and numerically shown that the Project team 6 (PT 6) is the best project proposal out of total of 7 proposals. Also, the project proposal of Project team 2 is by far the worst one.

Sometimes (in case of intersecting cones), PROMETHEE Diamond doesn't give to decision-maker the clear state of actions rank-position. In that case, he should gain an insight in other visual representations of the result or in other numerical outputs. This happened in the case of PT 3 and PT 5. By graphical display of results (Fig. 3) it is not clear which action is better, but if one look into Table 3 it clearly shows that PT 3 is slightly better than PT 5.

5 CONCLUSION

We presented a model for evaluating and ranking student project proposals based on multiple-criteria analysis — PRIMO. The model PRIMO was fed with course information and data from faculty course database, followed by the hierarchical structure of the goals and the criteria for mutual comparison of project proposals. Implementing multiple-criteria analysis led to better quality, more consistent decisions in this demonstration.

This model is valuable because it improves the consistency of decision-making and gives the decision-maker a feeling of safety because he knows that, if he has followed the procedure proposed by the presented model, he did not bring a false decision but a decision that is rational, systematically and carefully considered and based on compromise. The advantage of such approach to decision-making lies in the fact that even if it comes to a change in the structure of decision-makers, or the structure of decision subject, the decision-making procedure itself remains consistent.

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