

A METHODOLOGICAL APPROACH FOR THE SELECTION OF AN UNDERGRADUATE CURRICULUM IN DESIGN BASED ON AHP AND PROMETHEE MULTICRITERIA TECHNIQUES.

Mónica García Melón¹, Jaime A. Aguilar Zambrano², Pablo Aragonés Beltrán¹, Rocio Poveda Bautista¹

¹Universidad Politécnica de Valencia

²Pontificia Universidad Javeriana - Cali

ABSTRACT

This paper presents a new methodological approach for the selection of an undergraduate curriculum in Design. Unlike other current techniques for the selection of curricula based exclusively on disciplinary and academic factors, the proposal presented here also includes socio-economic aspects, employability, and the novelty of the disciplines. This innovative approach is in agreement with the new theories on higher education in this society of knowledge as well as it offers a holistic view of the curriculum. The proposed methodology, in turn, is cooperative, favouring interaction with other disciplines and thus enriching the curriculum as a whole.

This methodology is based on the combined application of two discrete multicriteria decision techniques: Analytic Hierarchy Process (AHP) [1] and PROMETHEE [2]. It shows by means of an application that the hybrid method is very well suited as a decision-making tool for curricular selection.

For model validation purposes, the methodology has been applied to the selection of a curriculum in Design for the Universidad Pontificia Javeriana at Cali (Colombia). This University is a private institution managed by the Society of Jesus.

Keywords: Higher education, AHP, Promethee

1. INTRODUCTION

The design and planning of higher education curricula has usually been based on scientific and academic criteria selected by the Departments and Schools of the University involved in the process, but no guarantee of social usefulness was granted.

On most occasions the Universities design a new curriculum based on improvements on already existing curricula at the University. In this paper we propose a new method for the selection of undergraduate course contents through the analysis of other university curricula. In particular, this new approach allows the incorporation of the curricular elements in the economic and social context, the educational expectations of the undergraduate students, labour opportunities of the graduates and the university's primary functions.

For the incorporation of all these factors in the selection process and the active engagement of experts in Design, Multi-Criteria and multi-Expert Decision Analysis techniques are used.

In this paper, Multi-Criteria Decision Analysis (MCDA) is proposed as a tool for helping in the selection of the best curriculum. MCDA “is a term that includes a set of concepts, methods and techniques that seek to help individuals or groups to make decisions, which involve several points of view in conflict and multiple stakeholders” [3]. All these MCDA concepts and methods have been largely studied in the Operational Research Literature [4][3][5].

The selection of a mathematical model based on MCDA is not an easy task. According to Bouyssou et al. (2000) [6], there are several models that can be used in a decision-making process. There is no best model. In this paper, two well-known MCDA techniques are used: Analytic Hierarchy Process (AHP) [1] and PROMETHEE II [2]. It shows by means of an application that the hybrid method is very well suited as a decision-making tool for curricular selection.

In the field of higher education the MCDA techniques have already been used by different authors [7]. AHP has been applied in Evaluation of university faculty for tenure and promotion [8], Selection of university teachers [9], Improvement of the quality of teaching [10], Selection of Information Systems in universities [11], University facilities planning [12] and Improvement of education quality in industrial engineering [13]. On the other hand, PROMETHEE has not been used in the field of higher education yet. No references particularly related to undergraduate curriculum selection have been found.

The proposed decision model is innovative in terms of consistency with the new theories for higher education, for which aspects such as social environment, job market and new disciplines are considered as important factors within a holistic approach. This does not mean that a University should make its decisions based exclusively on market demand, but it should not use the academic looking-glass criterion alone in the selection of the curricular contents.

The model proposed here has been applied to the selection of curricula in the Design field for a private university in Colombia, based on the analysis of nine curricula in Design selected from 51 universities worldwide.

2. DESCRIPTION OF AHP AND PROMETHEE METHODS

2.1. The AHP method

The Analytic Hierarchy Process (AHP) developed by Saaty is a measurement model of intangible criteria [14]. AHP is based on the fact that the inherent complexity of a multiple criteria decision making problem can be solved through the construction of hierarchic structures consisting of a goal, criteria and alternatives.

At each hierarchical level paired comparisons are made based on value judgements using numerical values taken from the AHP absolute 1-9 scale. These comparisons lead to dominance matrices from which ratio scales are derived in the form of main eigenvectors. These matrices are positive and reciprocal ($a_{ij} = 1/a_{ji}$). The synthesis of AHP combines multidimensional scales of measurement into a single one-dimensional scale of priorities. For mathematical details see [15][16].

The method has the additional advantage of being easy to explain to the experts that have to assess the different criteria in a simple and systematic way. The support software, Expert Choice 2000, also enables the calculations and graphical representation of the results to be done easily and quickly.

2.2. The PROMETHEE methods

The PROMETHEE I and II methods belong to the family of the outranking methods in MCDA [17].

The PROMETHEE I partial ranking provides a ranking of alternatives. In some cases, this ranking may be incomplete. This means that some alternatives cannot be compared and, therefore, cannot be included in a complete ranking. This occurs when the first alternative obtains high scores on particular criteria for which the second alternative obtains low scores and the opposite occurs for other criteria. The use of PROMETHEE I then suggests that the decision-maker should engage in additional evaluation efforts.

PROMETHEE II provides a complete ranking of the alternatives from the best to the worst one. Here, the net flow is used to rank the alternatives.

In this paper PROMETHEE II has been chosen because the objective is to obtain a complete rank order of the different alternatives.

For that, the algorithm of the method starting from the evaluation matrix associates a Preference Function (Generalised Criterion) to each criterion considering the difference on values between the alternatives for this specific criterion. This Preference Function takes values between 0 and 1 and allows the establishment of indifference and preference thresholds. In order to facilitate the selection of a specific preference function, six basic types have been proposed [18][19][20].

3. METHODOLOGY

The proposed methodology consists of the following steps:

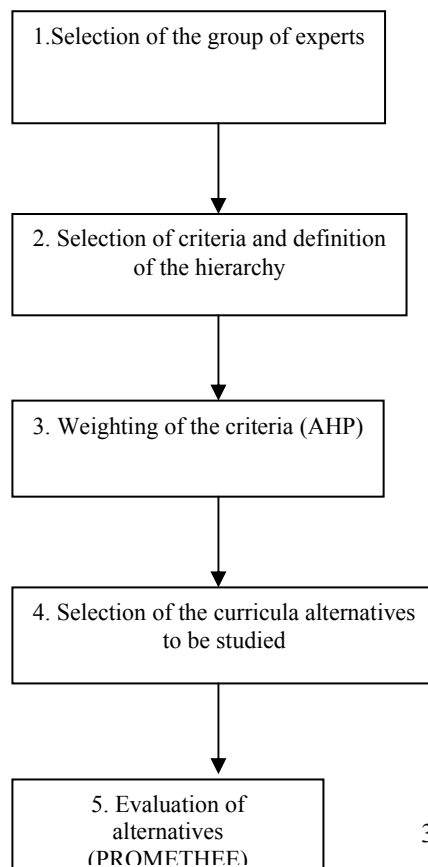


Figure 1. New Methodology for the selection of an undergraduate curriculum in Design

Step 1. Selection of the group of experts

For a better quality of the results, it is convenient to count with a group of experts in Design [21]. The working team should include at least one staff member from each faculty [22]. The experts are selected taking into consideration their knowledge and experience in Design, and their available time to engage in the project [23]. Additionally, the experts selected are expected to provide sincere and unbiased answers to the questions [24].

Step 2. Selection of criteria and definition of hierarchy

The problem of curriculum selection should take into consideration the influence of the curriculum on the environment, considering it as a whole [25]. By environment we refer to the local social and economic factors, the university functions and the students' satisfaction in terms of academic outcomes and future job market opportunities. This way of approaching curricular planning agrees well with the considerations of Mode2 University, in this society and economy of knowledge, characterised by the following features: "first, it is closer to government and the market and is more directly responsive to national and regional needs in teaching, research and specific enterprise activities. Second, it conducts research in an interdisciplinary fashion and according to new criteria such as economic and social relevance. Third, it is innovative and interacts in a number of different networks and it is a key player in evolving systems of regional and local governance." [26]. Based on these factors, the experts define the best criteria for curriculum content selection.

Step 3. Weighting of criteria

Following the AHP approach, through a pairwise comparison mechanism the experts determined the relative importance of each criterion defined in step 2, issuing their value judgements individually according to their knowledge and experience and on the basis of a set scale, Saaty's scale, as explained in paragraph 2.1.

- 1: objective 1 and objective 2 are considered equally important
- 3: objective 1 is considered slightly more important than objective 2
- 5: objective 1 is considered considerably more important than objective 2
- 7: objective 1 is considered much more important (or demonstrably more important) than objective 2
- 9: objective 1 is considered absolutely more important than objective 2

The design of the questionnaire is very important since it has to be comprehensive and understandable to all the experts taking part in the evaluation process.

The answers to the questions are used to complete all the entries of the pairwise comparison matrix, from which the priorities associated to each criterion are calculated, as suggested by the author of the method [1]. The inconsistency of the experts' judgements should not be higher than 10%.

Once the questionnaires have been completed and the experts' priorities on the assessment criteria have been defined, a single priority value for the goals is calculated as the geometric mean value of the individual pairwise comparisons [1].

To facilitate decision makers with the task of rating the criteria, the following data were provided: i) the local context based on social and economic indicators, ii) statistical data of the labour market in the field of Design, iii) the opinions of other managers and developers of curricular programmes in the country to identify opportunities, iv) the desirable qualities a curriculum in Design should cover as recognised by renowned and experienced designers

Step 4. Selection and analysis of the alternatives to be studied

The experts had to gather information from governmental entities and professionals in Design and also review other curricula on offer in various prestigious Universities in order to select the different alternatives to be analysed. The aim is to select a number of proposals in Design and evaluate them for the particular case of Valle del Cauca in terms of the benefits generated to the community through their products, services and systems.

The different proposals selected are then analysed in detail for a better understanding of the real context.

Step 5. Evaluation of alternatives

Finally, the analysed proposals have to be prioritised using the PROMETHEE technique, based on the assignment of specific utility functions to each criteria. In this step, it is recommended to use this technique because with AHP, the decision problem is decomposed into a number of subsystems, within which and among which a substantial number of pairwise comparisons need to be completed. Hence AHP has the disadvantage that the number of pairwise comparisons to be made may become very large (more specifically: $n(n-1)/2$). PROMETHEE needs much less inputs. Only the evaluations have to be performed of each alternative on each criterion.

In the end, the final report will be handed over to the academia authorities of the University.

4. CASE STUDY: SELECTION OF A NEW UNDERGRADUATE CURRICULUM IN DESIGN FOR THE UNIVERSIDAD PONTIFICIA JAVERIANA AT CALI, COLOMBIA.

In order to demonstrate the usefulness of the proposed decision model, the method has been applied to the development and planning of a new curriculum in Design for the Universidad Pontificia Javeriana at Cali (Colombia).

This University is a private institution managed by the Society of Jesus, located in Cali, capital city of the Department of Valle del Cauca in Colombia. The Department of Valle del Cauca is an area with an important production in sugar cane and tropical fruits, with a great natural potential due to its great biodiversity and has the main harbour in the Pacific Ocean.

The steps proposed in the methodology were conducted in the following way:

Step 1. Selection of the group of experts

The University selected an assessment committee consisting of 7 members, three representatives of the three Faculties of the University –Faculty of Economics and Administration Science, Faculty of Engineering and Faculty of Humanities and Social Sciences- the Head of the Computer Services, the Head of the International Relations, and the Assistant Technician of the Analysis and Development Unit belonging to the Vice-rectorate for Academic Studies. The group was created and coordinated by the Vice-rector for Academic Studies who is the person in charge of curricular planning and management at the University.

The assessment committee in turn chose two members for steps 3,4 and 5 –an industrial designer with business, teaching and educational administration experience, and an electrical engineer with teaching and university administration experience and a product developer with multidisciplinary teams. These two members periodically informed the committee on their advances and progress.

Step 2. Selection of the criteria

The following choice of first-level criteria was selected under consideration of the factors mentioned in step 2: Relevance with the environment [4], Relationship with the University[13][25][27], Novelty of the Disciplines [28] and Opportunities in the job market [29][25].

For the criterion of *Relevance with the Environment* the experts analysed the governmental planning actions and policies, the prospective technological agenda of Valle del Cauca[8], and the national business management indicators [30][31]. For the analysis of *Relationship with the University*, the experts used the institutional documents about the educational Project, data on the facilities and infrastructures available at the University, the evaluation of the research lines of the university, and human resources. The criterion of *Novelty of the Discipline* was analysed based on the study of the curricula in Design imparted in the country through interviews with the managers and developers of the programmes, the historical evolution of the programmes worldwide and the design of a questionnaire on the preferences and expectations of incoming students. For *Job Market Opportunities*, the data sources utilised for the Environment criterion were also used here; additionally, a board of renowned national professionals in Design was established, and a statistical database about employment of graduates in Design was elaborated.

Figure 2 shows the hierarchy model of the decision problem whose main goal is the selection of the curricular contents in Design for a particular higher education institution

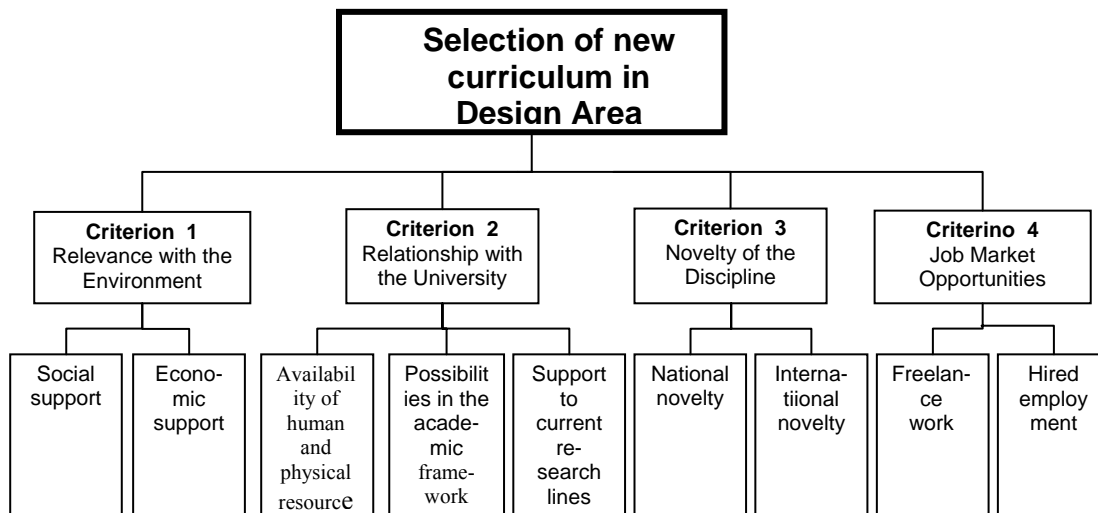


Figure 2. Hierarchy model for the selection of the curricular contents in Design

Step 3. Weighting of the criteria

Once the criteria have been defined, the AHP method allows the construction of a rank order of priorities among the criteria through pairwise comparisons.

For this purpose, a specific questionnaire was designed to obtain the judgements of the experts. After that, the weights were calculated with the aid of the EC2000 software, which allows both individual and combined (the mean value of the individual data) outcomes. It also enables inconsistencies to be analysed and solved.

For the development of a studies plan in Design for the Universidad Javeriana, which criterion is the most important and to which extent.					
<input type="checkbox"/> Relevance with the environment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Relationship with the university	Extreme	Very strong	Strong	Moderate	Indifferent
<input type="checkbox"/> Relevance with the environment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Novelty of the Discipline	Extreme	Very strong	Strong	Moderate	Indifferent
<input type="checkbox"/> Relevance with the environment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Opportunities in the job market	Extreme	Very strong	Strong	Moderate	Indifferent
<input type="checkbox"/> Relationship with the university	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Novelty of the Discipline	Extreme	Very strong	Strong	Moderate	Indifferent
<input type="checkbox"/> Relationship with the university	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Opportunities in the job market	Extreme	Very strong	Strong	Moderate	Indifferent
<input type="checkbox"/> Novelty of the Discipline	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> Opportunities in the job market	Extreme	Very strong	Strong	Moderate	Indifferent

Figure 3. Summary of the questionnaire for the weighting of the evaluation criteria

Before that, the assessment committee analysed in more detail other factors related to the evaluation criteria for a better judgement and weighting.

The data analysis enabled the assessment committee to issue judgements that were introduced into the Expert Choice software. The weights obtained for the different criteria are shown in figure 4.

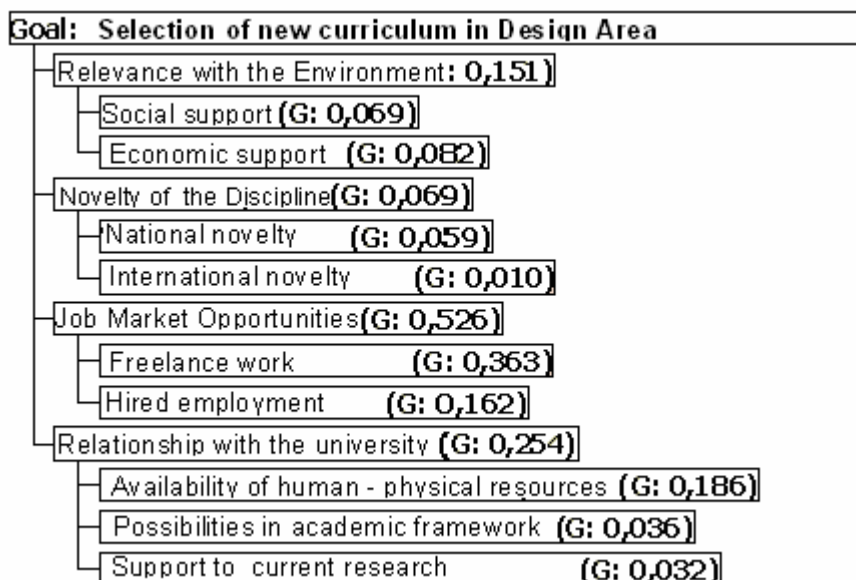


Figure 4. Weights of the evaluation criteria for the curriculum-selection model.

From the results in Figure 4 we can conclude that in the first-level set of criteria, the most preferred one corresponds to the criterion *Opportunities in the job market* (52.6%), with more than half the total weight. With respect to the second level, the criterion most highly rated by the experts is *Freelance work* (36.3%), secondly we have *Availability of Human resources at the University* (18.6 %), followed by *Hired Employees* (16.2%). The rest of criteria present weights lower than 10%.

The results suggest that curricular planning in higher education should take into consideration future opportunities in the job market.

Step 4. Selection and analysis of alternatives

The experts revised more than 90 curricula in Design worldwide and, based on the gathered information, they elaborated a database about duration of the studies, human and physical resources, research lines, and course contents. Table 1 lists the universities analysed for the study [32] through the information available on their websites.

Universities	Country
Umeå University	Switzerland
Istituto Europe de Design, Politecnico di Milano, Domus Academy	Italy
Central Saint Martins School of Art & Design, Royal College of Art.	United Kingdom
Köln International School of Design	Germany
Elisava escola de disseny	Spain
Delft University of Technology	Holland
University of Art and Design Helsinki UIAH	Finland
Ecole Nationale Supérieure de Création Industrielle -Les Ateliers	France
National Institute of Design	India
Istanbul Technical University	Turkey
Royal Melbourne Institute of Technology	Australia
Instituto Superior de Diseño Industrial ISDI	Cuba

Universidad de Buenos Aires	Argentina
Pontificia Universidad Católica del Perú	Peru
Instituto de Diseño de Caracas	Venezuela
Fundacao Armando Álvares Penteado- FAAP	Brasil
Universidad Autónoma de México	Mexico
Universidad del Bosque, Universidad Autónoma del Caribe, Universidad Pontificia Bolivariana, Universidad Jorge Tadeo Lozano, Instituto Departamental de Bellas Artes, Universidad de Boyacá, Universidad de Nariño, Universidad Católica Popular de Risaralda, Universidad de los Andes, Pontificia Universidad Javeriana, Universidad Industrial de Santander, Universidad ICESI, Universidad Eafit, Universidad Autónoma de Bucaramanga	Colombia
Pratt Institute, Massachussets Institute of Technology, Parson's school of design, College for Creative Studies, Illinois Institute of Technology, Carnegie Mellon University, Stanford University, Art Center College of Design, Rhode Island School, Rochester Institute of Technology, Yale University, Savannah College of Art & Design.	United States

Table 1. The Universities with Design studies analysed in this work

Nine different degree titles were analysed:

1. Product Design
2. Industrial Design
3. Engineering Design
4. Graphical/Communication Design
5. Digital Design
6. Broadcast Design
7. Design and Technology
8. Textile Design
9. Fashion Design

The curricula were analysed following the stated criteria and the questions of the questionnaire for further evaluation.

Step 5. Evaluation of alternatives

Finally, the analysed proposals were prioritised using the PROMETHEE technique, based on the assignment of specific preference functions to each assessment criterion.

For their judgements, the experts possessed detailed information of the curricula associated with every criterion of the lower hierarchy levels, as shown in Table 2. Prior to this, the experts had to follow a capacitance process on the operation of the proposed methodology. Promethee is a method that uses the evaluation matrix of the alternatives over a set of previously stated criteria.

For the present study, the experts were presented the different preference functions provided by Promethee (see paragraph 2.2.) for them to choose the functionality that best represented his/her preferences in terms of intensities for each assessment criterion. Due to the qualitative character of the criteria, they decided to work with the **function of usual criterion** since this function has no threshold. The weight of each criterion was defined by the weight values got through AHP. Table 3 shows an evaluation matrix corresponding to one of the experts; the experts' judgements were processed with the Decision Lab software.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
--	----	----	----	----	----	----	----	----	----

	C1	C2	C3	C4	C5	C6	C7	C8	C9
Product Design	7.0	9.0	7.0	7.0	7.0	9.0	5.0	5.0	8.0
Industrial Design	4.0	8.0	7.0	8.0	8.0	4.0	5.0	4.0	9.0
Engineering Design	4.0	9.0	8.0	8.0	9.0	9.0	7.0	3.0	8.0
Graphical/Communication Design	9.0	7.0	8.0	7.0	4.0	5.0	4.0	9.0	8.0
Digital Design	4.0	5.0	5.0	6.0	4.0	9.0	8.0	3.0	8.0
Broadcast Design	9.0	7.0	8.0	7.0	4.0	9.0	7.0	6.0	8.0
Design & Technology	4.0	4.0	5.0	5.0	5.0	10.0	9.0	3.0	8.0
Textile Design	3.0	4.0	2.0	2.0	2.0	7.0	6.0	4.0	8.0
Fashion Design	7.0	7.0	1.0	2.0	1.0	6.0	5.0	9.0	7.0
Criterion weights	7.0	9.0	7.0	7.0	7.0	9.0	5.0	5.0	8.0

Table 2. Promethee Evaluation matrix associated to one of the experts

where:

- | | |
|--|---|
| C1: Social support. | C6: National Novelty |
| C2: Economic support | C7: International Novelty |
| C3: Availability of human and physical resources | C8: Freelance work |
| C4: Possibilities in the academic framework | C9: Opportunities in the job market as hired-employee |
| C5: Support to research lines | |

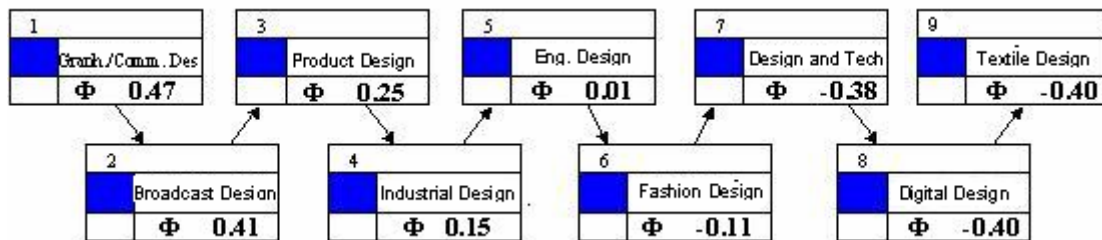


Figure 5. Results of curricular selection in Design using Promethee

The results obtained with Promethee and the combined judgements of the two experts can be seen in Figure 4, with the following rank order: (1) Graphical/Communication Design, (2) Broadcast Design, (3) Product Design, (4) Industrial Design, (5) Engineering Design, (6) Fashion Design, (7) Digital Design, (8) Design & Technology, and (9) Textile Design.

The outcomes built upon the judgements and evaluations of the two experts were presented to the assessment committee, which then decided to generate and prioritise strategies for the design of a Curriculum in Design, i.e., first the planning and development of the best ranked curriculum, and after its implementation, the planning of the other curricula.

5. CONCLUSIONS

In this paper, a new methodology for curriculum selection has been presented, based on MCDA techniques. The use of these techniques has allowed the integration of conventional disciplinary and academic factors as well as socio-economic aspects such as employability and discipline innovation and novelty. In this sense, the proposed decision model is consistent with the new theories on higher education in a society of knowledge and within the holistic approach of curricular planning. In addition, this method is cooperative as it allows the participation of experts of different disciplines, which enriches the meaning of curricular planning and reduces the intrinsic biases inherent to any selection or decision-making process.

For model validation, the proposed method has been applied to the particular case of the selection of a new curriculum in Design for the Universidad Pontificia Javeriana at Cali (Colombia).

The methodology was implemented by a group of experts with experience and deep knowledge in Design chosen by the University management board.

The choice of factors and criteria has been selected in agreement with the group of experts. The rank order of the evaluation criteria stresses the importance of employment and social environment as key factors, which has traditionally been covered by other university's objectives. The criteria were weighted using the AHP technique.

The experts also had to select the curricula in Design to be evaluated. Nine alternatives were chosen among the Design curricula from 51 different universities around the world.

The evaluation and ranking of the curricula was performed using Promethee.

The outcomes show that the best rated Design curriculum is Graphical/Communications Design. These results helped the university authorities to better plan strategies for the development of undergraduate curricula in Design, the best ranked being the first one to be implemented.

REFERENCES

- [1] Saaty TL. The Analytic Hierarchy Process. RWS Publications: Pittsburgh; 1980.
- [2] Brans, J.P., 1982. L'ingénierie de la décision. Elaboration d'instruments d'aide à la décision. Méthode PROMETHEE. In: Nadeau, R., Landry, M. (Eds.), L'aide à la décision: Nature, instruments et perspectives d'avenir, Presses de l'Université Laval, Québec, Canada. pp. 183–214
- [3] Belton, V. and Stewart T. Multicriteria Decision Analysis, 2003 (Kluwer Academia Publishers).
- [4] Pomerol JC, Barba-Romero S. Decisiones multicriterio: fundamentos teóricos y utilización práctica. Universidad de Alcalá de Henares: Alcalá de Henares; 1997.
- [5] Figueira J., Greco S., Ehrgott M. (2005); Multiple criteria decisión analysis: state of the art surveys, Springer, New York
- [6] Bouyssou, D., Marchant, T., Pirlot, M., Perny, P., Tsoukias, A, and Vincke, P. (2000), Evaluation and Decision Models: A Critical Perspective. Kluwer Academic Publishers, Boston,
- [7] Vaidya, O. and Kumar, S. Analytic hierarchy process: An overview of applications. European Journal of Operational Research, 2006, 169(1), 1–29.

- [8] Bryson N. and Mololurin A. An action learning evaluation procedure for multiple criteria decision making problems. *European Journal of Operational Research*, 1997, 96 (2), 379-386.
- [9] Bahurmoz A. The analytic hierarchy process at DarAl-Hekma, Saudi Arabia. *Interfaces*, 2003, 33 (4), 70-78.
- [10] Lam K and Zhao X. An application of quality function deployment to improve the quality of teaching. *International Journal of Quality & Reliability Management*, 1998, 15 (4), 389-413.
- [11] Kwak N. and Changwon L. A multi-criteria decision making approach to university resource allocations and information infrastructure, *European Journal of Operational Research*, 1998, 110 (2), 234-242.
- [12] Benjamin C. et al. Planning facilities at the University of Missouri-Rolla, *Interfaces*, 1995, 22 (4), 95-105.
- [13] Koksals et al. Planning and Design of Industrial Engineering Education Quality. *Computers Industrial Engineering*, 1998, 35 (3), 639-642.
- [14] Saaty TL. *Decision making with independence and feedback: The Analytic Network Process*. RWS Publications: Pittsburgh; 2001.
- [15] Saaty TL. *Fundamentals of decision making and priority theory with the AHP*. RWS Publications: Pittsburgh; 1994.
- [16] Saaty TL. *The analytic hierarchy process: planning, priority setting, resource allocation*. RWS Publications: Pittsburgh; 1996.
- [17] Brans, J.P. The space of freedom of the decision maker. Modelling the human brain. Euro gold metal. *European Journal of Operational Research* 92 (1996), pp. 593-602.
- [18] Brans, J.P., 1982. L'ingénierie de la décision. Elaboration d'instruments d'aide à la décision. Méthode PROMETHEE. In: Nadeau, R., Landry, M. (Eds.), *L'aide à la décision: Nature, instruments et perspectives d'avenir*, Presses de l'Université Laval, Québec, Canada. pp. 183-214
- [19] Brans, J.P. and Vincke, Ph., A preference ranking organization method: The PROMETHEE method. *Management Science* 31 (1985), pp. 647-656
- [20] Brans, J.P. and Mareschal, B., The PROMCALC and GAIA decision support system for MCDA. *Decision Support Systems* 12 (1994), pp. 297-310.
- [21] Aragonés, P., Gómez-Senent, E., Pastor, J., Ordering the Alternatives of a Strategic Plan of Valencia (Spain). *Journal of Multicriteria Decision Analysis* 2001, 10 (3), p. 153-171
- [22] Jharkharia, S., Shankar, R., Selection of logistics service provider: An analytic network process (ANP) approach *Omega*, 35 (3), 2007, Pages 274-289
- [23] Goodwin, P., Wright, G. *Decision Analysis for Management Judgment*. John Wiley and Sons, 2004
- [24] Saaty, T.L., Shang, J.S., Group decision-making: Head-count versus intensity of preference *Socio-Economic Planning Sciences*, Volume 41, Issue 1, March 2007, Pages 22-37
- [25] Yorke et al. Curricula for economic and social gain. *Higher Education*, 2006, 51(4), 565-588.
- [26] Harloe et al. Universities, Localities and Regional Development: The Emergence of the 'Mode 2' University?. *International Journal of Urban and Regional Research*, 2004, 28(1), 212-223.
- [27] Arocena R. and Sutz J. Latin American Universities: From an original revolution to an uncertain transition. *Higher Education*, 2005, 50(4), 573-592.
- [28] Dyrddal et al. Professional responsibility - an issue for higher education?. *Higher Education*, 2006, 52(1), 95-119.
- [29] Garraway, J. Creating productive interactions between work and the academy. *Higher Education*, 2006, 52(3), 446-464.
- [30] Cámara de Comercio de Cali. *Revista Acción*, 2004, 53,1-30.
- [31] La nota económica S.A. *Vademécum de mercados*. Nota Económica, 2004.
- [32] URL: <http://www.design.puj.edu.co>