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A new method to assess how curricula prepare students for the workplace in higher education

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ABSTRACT

Curricula are an essential ingredient of academic activity in higher education institutions and so it is necessary to develop tools that help improve these curricula. The need to increase student employability has recently been highlighted as an objective for universities. This paper introduces a methodology to help assess curricula in the training of skills for the labor market. Using a combination of the technique for order preference by similarity to the ideal solution (TOPSIS) method and an adaptation of importance-performance analysis (IPA), this methodology measures the gap between graduate perceptions of their university training and of its workplace utility. A dataset of 15,339 graduate opinions was used to analyses the mis match between the two perceptions. To measure these differences, an index was drawn up enabling quantitative comparisons among subject areas. A ranking is provided, as well as guidelines for enhancing curricula.

KEYWORDS

Student perception; curriculum satisfaction; skills acquisition; multicriteria decision aiding

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Introduction

Policymakers, including the European Commission (European Commission, 2011), have called for higher education institutions (HEI) to respond to the economic and social challenges facing young people. Specifically, according to Teichler (2009), in the new context of increasingly scarce resources and high unemployment, policymakers have tried to raise HEI awareness of the needs of the labor market and so help increase the employability of their graduates. According to Sin and Neave (2016) this objective was stated the 1999 Bologna treaty but has only been maximized in recent years.

These steps have unleashed a debate about the meaning and the ultimate goal of university. Boden and Nedeva (2010) discuss the commitment to employability itself, and Tomlinson (2012) speaks of "no longer being a graduate but an employable graduate". Tomusk (2004) notes increased economic rationing in HEI, which reinforces the Sin and Amaral (2017) definition of HEI as service providers. This has already become an argument for universities to enroll more students and so increase resources (Jackson, 2014). These policies were advanced in 2012 when the European Council set a benchmark for employ ability: graduate employment at 82% three years after completing the program.

Employability has since become a clear priority for European HEIs in general, and some authors emphasise the need to justify an efficient and accountable allocation of public funds (Maher, 2004). Better adaptation to the needs of economic and social development is also occurring outside Europe (Zhang, Shen, & Gao, 2016). Nevertheless, what activities are actually being done to increase that employability? Hart (2009) warned of the potential mismatch between jobs and skills acquired. One answer in higher education is the curriculum design (Sin & Amaral, 2017), and this paper is about how to see if this occurs. The aim of this study is to offer an analytical tool to diagnose and make decisions about the improvement of curricula, specifically in the skills to develop through it.
Spanish regulations classify higher education (HE) asa public service. The lion's share of higher education offering is provided by the public sector. Higher education accounts for almost 1% of Spain's GDP, with almost €9 billion spent on universities every year. Fifteen years ago, public quality agencies were founded to provide external quality

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assurance for the HE system and foster constant improvement through evaluation, certification, and accreditation. Since then, HE actors have worried over how to measure performance. The aforementioned changes in HE have made the tasks of performance measurement and improvement more challenging (Coates, 2016).

Literature review

Numerous studies highlight the importance of curricula as an essential element of higher education. Some researchers have described the major philosophies that in,luenced educators in the last century (Schiro, 2007) and others defined the educational project (Barnett, Parry, & Coate, 2001). The evolution of the term and a redefinition of the main activity from development to its comprehension has also been made (Pinar, Reynolds, Slattery, & Taubman, 2006). ome researchers focussed on the correct approach for its design and definition, while Nygaard, H0jlt, and Hermansen (2008) focused on the learning process of students. For Shay (2016) the discussion is whether knowledge, competence, or action should be enhanced. Others have focused on the process and stages (Viriansky & Raychuk, 2016), or on building a genuine form of education for a genuinely democratic society (Kelly, 2009).

How is a good curriculum recognised? For Maher (2004) the first response to the quality of a curriculum is the pedagogical design. For Ashwin (2014) the learning outcomes and the knowledge contained within are key. Lam and Tsui (2013) emphasise coherence between content and learning objectives, and Leathwood and Phillips (2000) point to integration between delivery and learning outcomes. Other authors indicate management methods - whether student-client satisfaction (Zhang, Wang, Min, Chen, & Huang, 2016) or service delivery (Noaman et al., 2015). Alves and Raposo (2007b) or Hartman and Schmidt (1995) reflect on satisfaction with a management approach and offer several models of measurement.

Some researchers are influenced by the pressure on employability and directly mea- sure it as such (Cheong, Hill, Fernandez-Chung, & Leong, 2016). Clarke (2018) and Holmes (2013) explain the term employability in depth. Other authors delve into a single subject and the variability of teaching quality (Bhatt, Koedel, & Lehmann, 2013), or a single competence (Paxton & Frith, 2014). As Becket (2008) states, there is no consensus on how to measure quality and manage it within an HEI, although designing, implementing, and renewing curricula are basic tasks for universities and hence, the need for a proper evaluation of curricula so that they can be improved and updated (Margolis, 2001).

Previous research and methodological approa.:hes

There are at least two key issues to address when trying to evaluate a curriculum: who will do it and what will be measured. As regards to the first question, there are basically four sources of opinion: students (Alves & Raposo, 2007a; Shah, Cheng, & Fitzgerald, 2017); external agents such as the labour market (Eurico, Da Silva, & Do

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Valle, 2015); or the same institutions through their staff or faculty (Bie & Meng, 2009; Duzevic & Ceh Casni, 201j). Onthesubject of measurement, some studies focus on the hidden curriculum (Kentli, 2009), the knowledge or skills it contains (Martfn, Potocnik, & Fras, 2017; Moore & Morton, 2017), satisfaction *(Voss,* Gruber, & Szmigin, 2007), perceptions on quality (Nadiri, Kandampully, & Hussain, 2009), the student experience (Ginns, Prosser, & Barrie, 2007; Goldfarb, Rivera-torres,& Martin, 2015), or incorporation into the labour market (Ren, Zhu, & Warner, 2015). The present study is based on the opinion of the students, as leading actors of the learning process, and their perception of how their education fits with the labour market; and measures the 14 essential skills considered by the public administration that finances the HE system (Agencia per a la Qualitat del Sistema Universitari de Catalunya [AQUJ, 2014). The first of the main direct antecedents of the present study is Moore and Morton (2017) which studies professional writing skills with a methodology based on semi-structured interviews. Another reference study is that of Martfn et al. (2017) which focuses on the capacity for innovation and how it is included in the curriculum. The research is methodo- logically based on a longitudinal study and questionnaires. Finally, there is research using importance-performance analysis (Silva & Fernandes, 2011) and focused on student percep- tions of quality measuring services (including the library or labs). Of course, when asking students it is important to assume that there may be a difference between students' perceptions and reality, as raised by Sahin & Helley (2006); thus, perception is based by definition on one's own criteria and perspective. There is a lack of studies addressing student skills and aptitudes needed for profes- sional life. This paper puts forward an innovative methodology that links the perceived level of training with perceived utility in the workplace. A "global discrepancy index" is then used to diagnose and enhance study plans. It is expected that the new tool will be useful for curriculum assessment and will help make decisions to improve curricula.

The paper is split intothree sections: the first describes the empirical research including the research approach, data collection, and the methodological approach. The second section analyses the results. The third section sets out our conclusions and discusses limitations.

Empirical research

All the data in this study come from a survey conducted by the official Catalan University Quality Assurance Agency (AQU, 2014). The main purpose of the AQU survey was to compile significant information at degree level on improving curricula and enhancing student job prospects. The Catalan higher education system is composed of 12 universities (seven public and five private) on 49 campuses (39 of which belong to public universities).

According to the Conference of Spanish Vice-Chancellors (Michavila, Martinez, & Merhi, 2015), the Spanish system at the time of the survey had a net schooling ratio of

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31% - which was the same as the EU average (the UK was 41% and Italy 16%). Catalonia and Spain were also average in terms of gender (slightly more women than men), age, and demanded subject areas (social sciences, management, and law being the most popular). In Catalonia, 70% of students enrol in public universities and 30% in private universities. Only one public university has less than 10,000 students while only two private universities have more than 10,000 students. Foreign students account for 5.5% of total enrolments in Catalonia (being almost 50% European) while in the Spanish system foreign students only account for 2.8%. When entering the labour market, 88% of students stay in Catalonia, while 5% travel abroad, and the remainder find employment in other Spanish regions.

All of the Catalan university system is represented in this survey. The study analyses the employment outcomes of 17,337 graduates, which represents 55% of the 31,279 who graduated at the end of the 2009-2010 academic year, with a sampling error of 0.51%. Respondents answered 82 questions on their socio-biographic background, study paths, transition from higher education to employment, early career, links between study and employment, self-assessment of their life goals and job prospects, as well as providing retrospective views on their HE experiences. Over 55% of respondents declared their work functions corresponded to the level of knowledge they had acquired at university. The data gathered and statistically described included employment rates, time taken to find a job, job environment, job sectors, etc. There was a section on job quality (that is to say, whether graduates felt they were working in the same field as their university studies), job duties, contractual factors, and so on. Tables 1-3 offer a sample of general results. The last section covered respondent satisfaction with university, for example, whether they would take the same degree again, mobility, etc. The raw data, presented in Tables 1-3, and the main contributions of the AQU study (AQU, 2014) form the starting point for our quanti- tative application.

Table 1. Activity area of employer.

Activity area of the company	
Agriculture, fishing and livestock	1.15%
Energy	1.57%
Cnemical inC:ustries	1.39%
Pharmaceutical and cosmetics industries	2.05%
Metallur.,;y and trans(J,•rt rr.aterial	4.80%
Food products and beverages	2.16%
Textiles, wood, paper and plastics	1.9::%
Construction	3.19%
Commerce	5.82%
Restaurants and catering	2.73%
Transport	2.72%
Comm.,nication technologies	4.79%
Media	2.03%
Finance institutions, insurance and property	16.33%
Public administration	4.76%
Education and research	22.:'4%

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Health	15.61%
Other services	3.97%
	100.00%

Table 2. Type of work contract.

Types of contract	
Don't know/No answer	0.10%
Full time	48.14%
Self-employed	11.18%
Part time	35.15%
Scholarship	4.2 %
Nocontract	1.21%
	100.00%

Table 3. Gross salary in €.

Gross salary €	
Don't know/No answer	5.74%
<9000	13.76%
9000-12,000	11.40%
12,001-15,000	14.07%
15,001-18,000	11.52%
18,001-24,000	1\1.38%
24,001-30,000	12.80%
30,001-40,000	7.42%
>40,000	3.91%
	100.00 %

Data collection

A specific set of variables from the AQU database was used for the purpose of this research - particularly information on graduate perception of the level of training received and its usefulness (or otherwise) in the workplace. Valid answers from 15,339 graduates on their degrees were analysed. There was a total of 128 study plans from 12 universities. These plans (curricula) covered the following subject areas: humanities; social sciences; experimental sciences; health; engineering & architecture.

Data were taken from the AQU section: "Assess your university studies and degree in connection with your needs in the workplace". The question put to graduates was: *'What is your opinion about your university studies? Rate from 1* to 7 *(where 1 is very poor and* 7 *is very good) the following 1spects of your university studies in relation to the level of training you received and your current needs in the worKplace.".* This was followed by a list of 14 items described as skills: including problem-solving, decision-making, teamwork, man- agement skills, oral expression, written expression, critical thinking, creativity, leadership, languages and computer skills, documentation skills, theoretical skills and practical skills. These 14 items were the most important for the public quality agency, so they are taken as a valid list. In any case, the focus of this study is on the methodology and not the specific 14 items (which could be substituted in other countries as necessary).

Methodological approach

The methodology proposed in this study combines different methods that

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include: a ranking process able to deal with ordinal assessments; a visual comparison of two rankings based on an IPA diagram; a measurement of the discrepancy between two rankings to analyse globally perceived differences and, finally, the prioritisation of actions to improve the required adjustment. Next, these four steps are described in detail.

Step 1: ranking process

The ranking process proposed in this paper is based on one of the most well-known distance-based methods to rank alternatives in multi-criteria decision-making: Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS), introduced by Hwang and Yoon (1981). This technique uses assessments of the alternatives and constructs a normalised decision matrix allowing comparison across criteria. Then it considers the distance between alternatives and certain target points, named "ideal positive solution" and "ideal negative solution" which model the best and the worst alternatives, respectively. The values of the distances are used to rank the given alternatives.

In this paper, we propose a Group Decision-Making (GDM) framework that combines the TOPSIS technique with the ordinal assessment over a set of skills, provided by a group of individuals in terms of linguistic judgements. All skills are assessed using a common ordinal scale allowing us to avoid normalising the decision matrix. Individuals are represented as Ii, and skills as C;. A detailed formulae of step 1 is depicted in Appendix 1.

We define now the "ideal positive skill" C.' and the "ideal negative skill" C- by considering the maximum and minimum, respectively, of the assessments from the individuals:

Then for each skill C; we calculate, respectively, the Euclidean distance from C' and c-,

o;, ando;, expressing the difference between each skill C; and the ideal negative and ideal positive, respectively. Finally, to rank skills the relative proximity to the ideal skill, denoted by O;, is computed for each C;. For each skill C;, O; expresses its relative distance to the ideal positive solution. Note that all values of the relative proximity will be between 0 and 1. The best skill will be the one with relative proximity closest to zero.

Let us consider an example to illustrate this step. Table 1 exhibits the results obtained using a subset of data from our real case.

Example 1.

Let us consider a set of skills $\{C,, C2, (3, (4\}$ where C, = theoretical training, C_2= practical training, C_3= oral expression, and C_4= writing expression. Let us define the decision matrix $(C;i)$ containing the assessment of ten individuals in relation to the perceived

level of training they received at university over this given set of skills (using an ordinal scale from 1 to 7). Each row corresponds to a different skill, and columns correspond to

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the opinion
of each individual. Matrix values (c#) can be seen in Table 1, together with the "ideal positive"
and "the ideal negative" skills. In addition, the relative proximity from $\{C_1, C_2, C_3, C_4\}$ to the "ideal positive skill" and the "ideal negative skill" together with the relative proximity to the ideal skill, are computed and presented in columns o•, o- and D of Table 4.

Table 4. Example of skills assessment in relation to perceived level of training.

Individuals' skills	1(1)	1(2)	1(3)	1(4)	1(5)	1(6)	1(7)	1(8)	1(9)	1(10)	O·	D·	D	Order	2.5·Order
C_1 : Theoretical training	4	6	4	5	7	6	3	6	3	7	2.45	8.66	0.22	1	1.5
C_2 : Practical training	5	5	6	3	2	2	3	4	3	5	7.42	5.10	0.59	3	-0.5
C_3 : Oral expression	3	5	2	5	4	1		5	4	5	8.00	3.32	0.71	4	- 1.5
C. : Writing expression	4	4	6	5	7	2		6	4	5	5.39	7.21	0.43	2	0.5
Ideal positive skill	5	6	6	5	7	6	3	6	4	7					
Ideal negative skill	3	4	2	3	2			4	3	5					

Step = visual comparison
To visually analyse the obtained rankings, an IPA methodology was considered for representing the ratings of several features on a two-dimensional chart. The classical IPA diagram was first proposed by Martilla and James (1977). Initially, the traditional IPA methodology was a representation of the importance-performance grid divided into four quadrants (1. low importance-low performance; 2. low importance-high performance; 3. high importance-low performance; 4. high importance-high performance). Due to improvements in the decision-making process, its ease of application, and the good results obtained, IPA has been implemented in several fields, such as marketing, operations, and human resources (Eskildsen & Kristensen, 2006; Gunasekaran, 2004; Park, Heo, Rim, & Park, 2008). It has also been adapted for use in the educational sector where IPA can be used, for example, to measure student perceptions (Silva & Fernandes, 2011).
Once the IPA diagram has been created, decisions can be made in several ways. In the quadrant model, the order of the features to be improved depends on their location in a specific quadrant of the grid, and in the diagonal model this order depends on their position relative to a diagonal line (the quadrant and diagonal models are the most widely used). Other researchers (Abalo, Varela, & Manzano, 2007) mix the quadrant and diagonal models. To better interpret the final grid, names are given to each quadrant to determine the highest and lowest improvement priorities. In our case, considering "perceived level of training" as the performance axis, and "perceived utility in the workplace" as the importance axis, the classical IPA diagram can be adapted as shown in Figure 1.
For instance, if a skill appears in the "concentrate here" quadrant, it means that
graduates participating in the survey perceive the level of training received with

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respect to this skill as "low", but evaluate it as being of "high" utility in the workplace.

Example 2.
Following Example 1, with the same set of skills $\{C_1, C_2, C_3, C_4\}$ and individuals assessing the skills in relation to perceived utility in the workplace, we have computed the corresponding relative proximity to the ideal skill, and then we have ranked the skills, as shown in Table 5.
As shown in Table 5, the relative proximity provides the following skills ranking: (4 >- (3 >- C, >- C2 and the IPA diagram presented in Figure 2.

Table 5. Skills assessment in relation to perceived utility in the workplace.

Individuals' skills	1(1)	1(2)	1(3)	1(4)	1(5)	1(6)	1(7)	1(8)	1(9)	1(10)	D*	D-	D	Order	2.5 -Order
(1 : Theoretical training	4	5	3	5	7	4		4	3	3	8.49	4.47	0.65	3	-0.5
C_2 : Practical training	5	4	3	6	6	1	1	4		1	10.63	1.73	0.86	4	-1.5
C_3 : Oral expression	6	4	2	7	6	2	7	5		6	5.74	8.43	0.41	2	0.5
(4 : Writing expression	6	4	S	6	7	6	7	6	1	7	2.45	10.77	0.19		1.5
Ideal positive skill	6	5	S	7	7	6	7	6	3	7					
Ideal negative skill	4	4	2	5	6			4							

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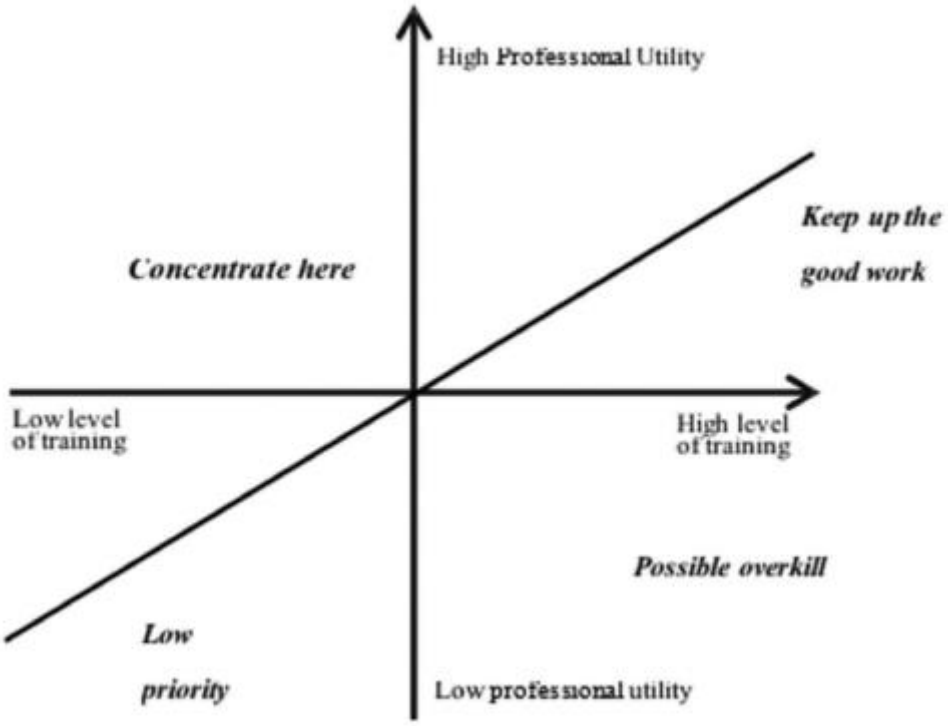

Figure 1. Adaptation of IPA diagram to skills in higher education.

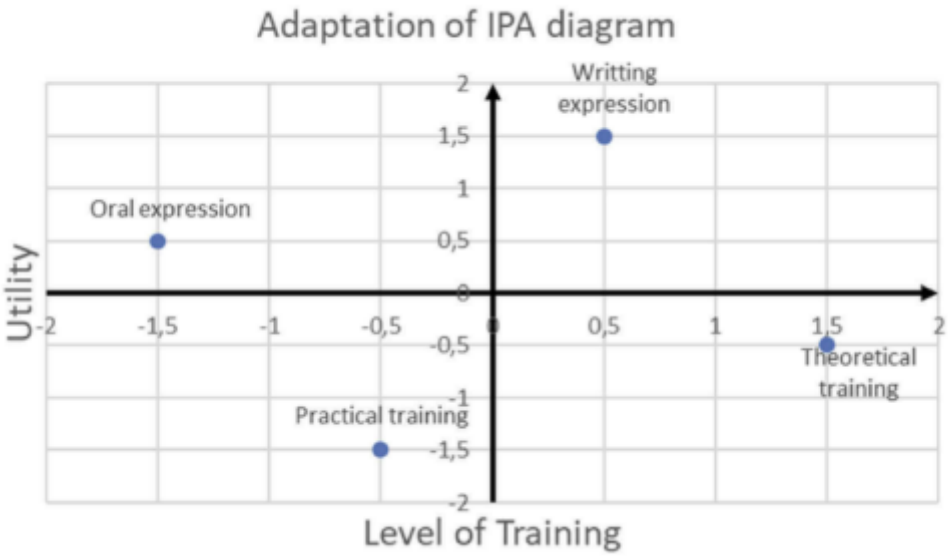

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Figure 2. Example of IPA diagram of skills in higher education.

Step 3: measure of discrepancy

Similarity indexes are commonly used in the literature to measure the discrepancy between rankings. Among these indexes, those based on induced ordered weighted averaging (IOWA) operators have been broadly studied in the literature (Chiclana, Herrera-Viedma, Herrera, & Alonso, 2007; Yager & Filev, 1999) and applied in multi-criteria decision-making when fuzzy or linguistic variables are considered (Herrera & Herrera-Viedma, 1997; Herrera-Viedma, Pasi, Lopez-Herrera, & Poree), 2006).In particular, the index applied in this paper, defined in Sayeras, Agell,Rovira, Sanchez, and Dawson (201S), compares two rankings of the same set of features. It is an extension of the classical IOWA operators that sensitively compare rankings by considering under-performing features. The definition of a global discrepancy index G (focussing on the skills for which resources must be allocated) is based on those skills whose position for perceived level of training in the ranking is worse than their position for perceived utility.
(See Appendix 1 for the mathematical definition of index G). Only positive differences between the "utility" and "level of training" are considered

Example 3.
Considering again the data used in Example 1, we obtain from Tables 1 and 2 the order of the four skills with respect to both "level of training" and "utility". The positive differences vector is (2, 1, 0, 0), and hence, the weights needed to compute the index: $w_1 = 0.4$; $w_2 = 0.3$; $w_3 = 0.2$ and $w_4 = 0.1$. The global discrepancy index is then: $G(2, 1, 0, 0) = 0.8 + 0.3 = 1.1$.

Step 4: prioritisation actions

Level curves are defined from the global discrepancy index to target and prioritise actions to improve performance. These actions enable decision-makers to obtain precise information on where to concentrate resources to improve the perceived level of training.
Features on the same level curves are those with the same level of discrepancy. The mathematical description of the level curves is given in Appendix 1. The representation of the level curves in the IPA diagram gives an order of prioritisation for the features that must be improved.

Example 4.
In Example 1, level curves of the marginal contribution of a skill in the G index are:

- $^{5}\underline{iv} \cdot (y - x) = k$. The skills with positive differences are, in the example, oral expression and writing expression and the corresponding marginal contribution in the G index

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are k = 3/5 and k = 4/5.

Representing some level curves together with the four skills chosen for this example, we observe that focus is needed on improving oral expression by students. Figure 3 shows an example of level curves of skills in higher education.

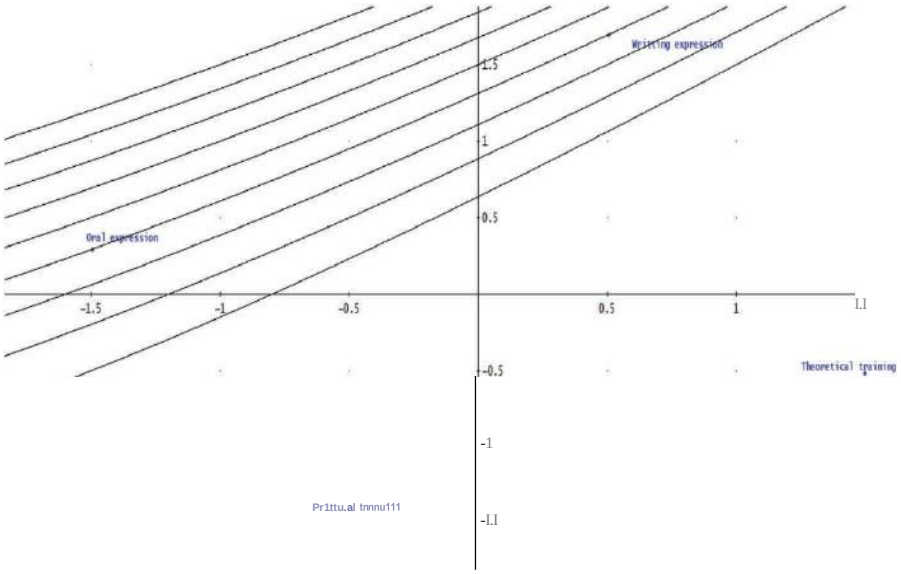

Figure 3. Example of level curves of skills in higher education.

Results

The results obtained by the application of the new methodology to the data set described in the research framework are shown in this section. Moreover, an order of subject areas was drawn up in terms of the need for curricular improvement. The illustrative case of humanities is highlighted and suggestions for improving their curricula are made.

Step 1: ranking process

Using the TOPSIS method described above, the 14 skills are ranked with respect to the two points of view evaluated. Results are shown in Table 6.
As shown in Table 4, and in the light of graduate perceptions, the skill with the highest level of training received was "theoretical training" and the lowest was

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"languages"; while

Table 6. TOPSIS score and ranking.

Level of training	S(i)	Order	7.5-Order	Utility in the workplace	S(i)	Order	7.5-Order
Theoretical training	0.33	1	6.5	Theoretical training	0.57	13	-5.5
Practical training	0.48	10	-2.5	Practical training	0.58	14	-6.5
Oral e,pression	0.46	8	-0.5	Oral expression	0.36	5	2.5
Writing expression	0.40	4	3.5	Writing expression	0.40	7	0.5
Team work	0.34	2	5.5	Team work	0.33	3	4.5
Leadership	0.55	13	-5.5	Leadership	0.45	10	-2.5
Problem solving	0.41	5	2.5	Problem solving	0.30	1	6.5
Decision making	0.45	7	0.5	Decision making	0.32	2	5.5
Creativity	0.49	11	-3.5	Creativity	0.45	11	-3.5
Critical thinking	0.38	3	4.5	Critical thinking	0.39	6	1.5
Management	0.46	9	-1.5	Management	0.36	4	3.5
Computer skills	0.51	12	-4.5	Computer skills	0.42	8	-0.5
Languages	0.71	14	-6.5	Languages	0.53	12	-4.5
Documentation skills	0.42	6	1.5	Documentation skills	0.45	9	-1.5

the most useful skill in the workplace was considered to be “problem solving” and the least useful “practical training”. It is important to note that this method does not average scores but compensates individual levels of perception as explained in the previous section. Removing the need to calculate the average of ordinal data makes the resulting ranking more precise. Step 2: visual comparison Observing Figure 2, the IPA diagram illustrates the skills and shows those in most urgent need of improvement in study plans, namely: management skills; oral expression; decision-making; problem-solving; computer skills; leadership; and languages. Figure 4 shows the IPA diagram of 14 skills in the curricula (two points of view). Step 3: measure of discrepancy Computing the global discrepancy index, which will become our mean and reference, with n = 14 the score obtained is 2,429:

$$G(X_1,\ldots,X_{14}) = \sum_{i=1}^{14} w_i X_i$$

Where $w_i = \frac{15-i}{105}$ for all I = 1, …, 14. As proven in Sayeras et al. (2015), in our case:

$$0 \leq G(X_1,\ldots,X_{14}) \leq 5.67.$$

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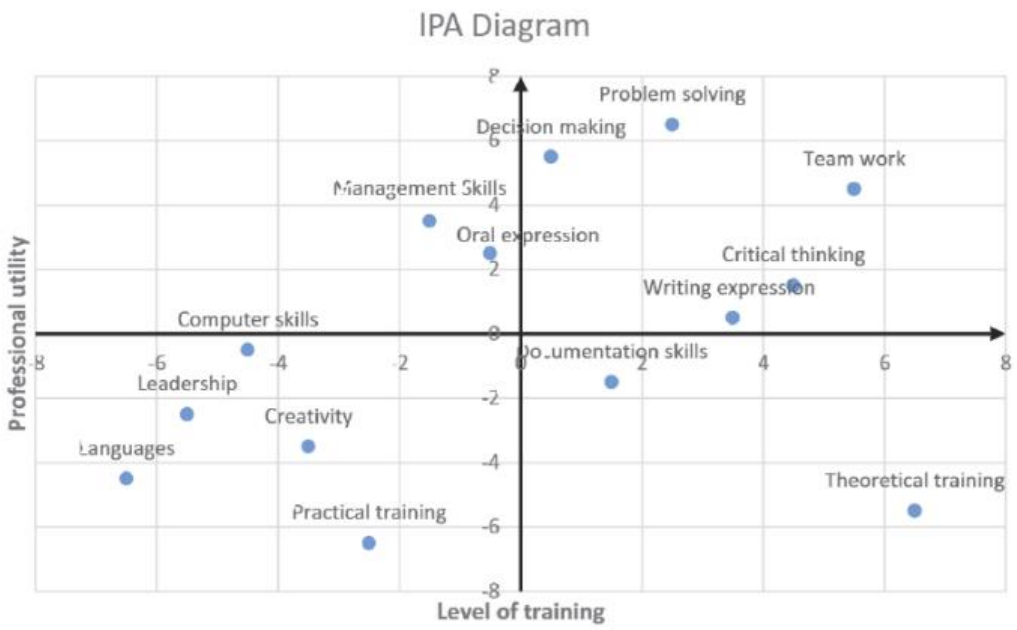

Figure 4. IPA diagram of 14 skills in the curricula (two points of view).

Step 4: prioritisation actions

Seven skills are still too many to focus on, and so a level curve analysis is performed, and curves are drawn (Figure SJ on the IPA diagram to highlight those skills that most need improvement.

To clarify the meaning of multiple curves in Figure 5, let us include the description of

how they have been found. Each curve contains all the points in the IPA Diagram having the same measure of discrepancy. It will allow us to reduce the number of competences to focus on. There are 7 competences over the diagonal, but observing the level curves, we see which those competences are as they are placed on the more external level curve, that is with a higher measure of discrepancy.

The diagnosis is now complete: from the graduate perspective, to enhance study plans **will** mean focusing on improving student decision-making, problem-solving, and management skills.

Subject area analysis

Once the general analysis has been completed, it can be applied to see if all the subject areas are rated similarly, and if the presented methodology can be applied at a lower level of analysis. To this end, the corresponding global discrepancy indexes are compared.

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The specific ranking for each subject area was calculated, as well as the integrated index of all the skills for each subject area. These subject areas were given a better or

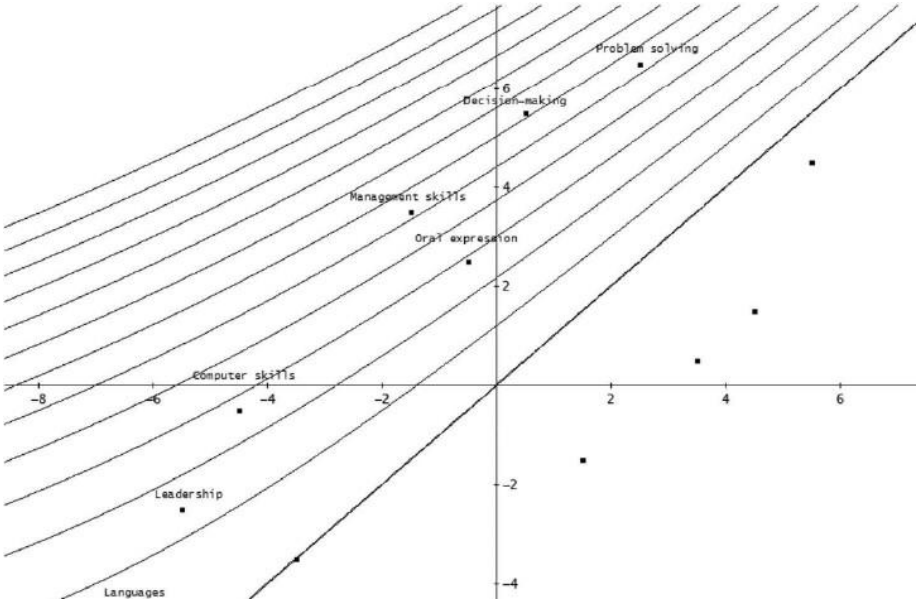

Figure 5. Level curves for IPA diagram for the curricula.

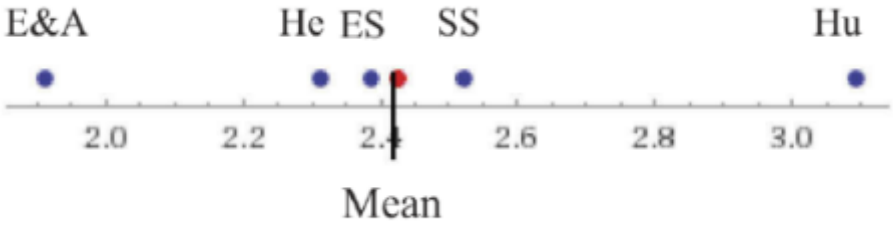

Figure 6. Comparison of global discrepancy index by subject area.

Table 7.
Global discrepancy index scores for subject areas.

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3095	:lumanities (Hu)
2524	Social Science (55)
2390	Experimental Sciences (ES)
2314	;iealth (He)
1914	Engineering'.Architecture (E&A)
2429	Mean

worse score depending on the discrepancy, and the scores were ranked and compared to the mean as shown in Figure 6 and Table 7. Therefore, as shown in Figure 4, some subject areas need to accelerate their improvement process. The study focuses on the humanities given that this area received the worst score.

Prioritisation actions for the humanities

For the humanities, as shown in Figure 7, "problem-solving" can be seen as the skill with the highest marginal contribution to the index, and so it is the priority - followed by decision-making. Regardless of whether courses in humanities must train students in "problem-solving" or "decision-making" for their professional life, the method has identified priorities.

Conclusions

This study introduces a new methodology for assessing university curricula. It focuses on student performance in professionally relevant skills. To this end, the training delivered and its perceived usefulness in the workplace are compared. Graduates who received the training are surveyed to analyse this performance. This enables academic managers to identify those areas needing improvement. The innovative contribution of the proposed methodology is that features are drawn in a new type of diagram for diagnosis.

Results obtained from the data collected in a survey by the Catalan University Quality Assurance Agency enable comparisons and identification of similarities and differences among the five principal fields of study (namely: humanities; social sciences; experimental sciences; health; engineering & architecture). The results show that the Catalan university system is performing properly at our level of analysis, but that some subject areas are performing better than others. Humanities is the field of study with the highest index score, meaning that it is the subject area with the widest gap between the level of training delivered and its perceived usefulness in the workplace. Specifically, the worst skills training is

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found in the areas of problem-solving, decision-making, and management.

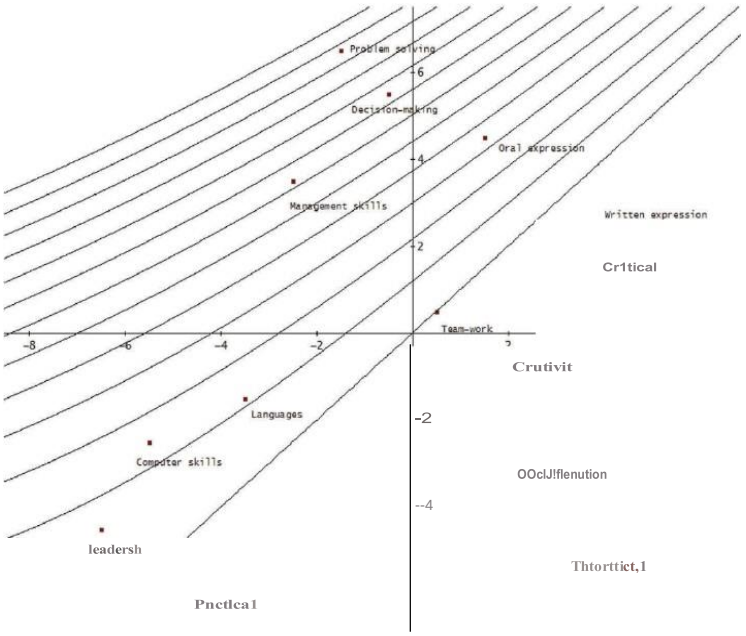

Figure 7. Level curves for curricula in the humanities.

skills. At the other extreme, engineering & architecture shows the lowest global discrepancy index - revealing fewer mismatches between training and professional utility.

This research does not intend to discuss which specific skills are the most necessary or useful for finding employment and uses those skills tracked by the official Catalan quality assurance agency. Nor does the research intend to evaluate the result of the comparison between subject areas; it seems reasonable that some subjects offer more of what the labour market demands. The aim of this study is to offer an analytical tool to diagnose and make decisions about the skills to develop in the curricula. A new quantitative method has been tested with potential reliable results for a large size sample and this is the scientific contribution to the field. The validity of these results remains internal as a construct, and its external or predictive validity is not yet established. This research follows the line of studies previously carried by Martin et al. (2017) and Moore and Morton (2017) for measuring a curriculum; Sin and Amaral (2017) for the study of employability and Melguizo and Wainer (2016) and Shah et al. (2017) for the presentation of a region around the

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world to share the case.
We make the following suggestions for future research. Firstly, this study could be extended by introducing more factors to measure performance and importance. Secondly, the perspective of other actors (mainly employers and faculty) could be presented and the performance of competitors considered. Thirdly, the study could be replicated and extended to more countries - something that would enable the comparison of results wherever similar surveys are used. All this further research would contribute to a final study to determinate the reliability and validity of this tool.

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Appendix 1: Detailed methodological approach

In this annex we describe in depth the mathematical development considered in the different steps of the methodological approach section

Step 1: Ranking process
Let (c;) be the mxn decision matrix where ci; is the assessment of individual Ij,j = 1,...., n, over the kill Cj, i=1,.....m.

$$\begin{array}{c} Skills \backslash Indiv \\ C_1 \\ \vdots \\ C_m \end{array} \begin{array}{c} \begin{array}{ccc} I_1 & \cdots & I_n \end{array} \\ \begin{pmatrix} c_{11} & \cdots & c_n \\ \vdots & \ddots & \vdots \\ c_{m1} & \cdots & c_{mn} \end{pmatrix} \end{array}$$

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Without any previous aggregation or normalization, we define the "ideal positive skill" C^* and the "ideal negative skill" C^- by considering the maximum and minimum respectively of each column:
$C^* = (c_1^*, \ldots, c_n^*)$, where $c_j^* = \max_i c_{ij}$, and $C^- = (c_1^-, \ldots, c_n^-)$, where $c_j^- = \min_i c_{ij}$.
Then for each skill C_i we calculate, respectively, the Euclidean distance from C^* and C^-, i.e. $D_i^* = \sqrt{\sum_j \left(c_{ij} - c_j^*\right)^2}$, and $D_i^- = \sqrt{\sum_j \left(c_{ij} - c_j^-\right)^2}$, expressing the difference between each skill C_i and the ideal negative and ideal positive respectively. Finally, to rank skills the relative proximity to the ideal skill is computed for each C_i as follows: $D_i = \frac{D_i^-}{D_i^* + D_i^-}$. The best skill will be the one with relative proximity closest to zero.

Step 2: Visual comparison
To visually analyse the obtained rankings, an IPA methodology was considered for representing the ratings of several features on a two-dimensional chart. We consider 'perceived level of training' as the horizontal axis, and 'perceived utility in the workplace' as the vertical axis.

Step 3: Measure of discrepancy
The definition of a global discrepancy index (focussing on the skills for which resources must be allocated) is based on those skills whose position for perceived level of training in the ranking is worse than their position for perceived utility. Only positive differences between the 'utility' and 'level of training' are considered, as shown in the following definition:

Let (X1,&,Xn) be the positive differences vector, n being the number of features that have been evaluated. The global discrepancy index 'G' of the firm is:

$$G(X_1, \&, X_n) = \sum_{i=1}^{n} w_i X_i$$

where weights are computed using the Borda–Kendall method (Kendall 1948), i.e., $w_i = \frac{2(n-i+1)}{n(n+1)}$ for all i = 1, …, n. Note that $w_i \epsilon [0, 1]$ and $\sum_{i=1}^{n} w_i = 1$. Weights decrease from $\frac{2n}{n(n+1)}$ to $\frac{2}{n(n+1)}$. In this way, skills with greater differences have greater weights in the weighted mean defining the global discrepancy index $G(X_1, \&, X_n)$."

Step 4: Prioritisation actions Level curves are defined from the global discrepancy index to target and prioritise actions to improve performance. As proven in (Sayeras et al., 2015), the level curves of the marginal contribution of a feature in the G index in the IPA diagram are:

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$$\frac{n+1+2y}{n(n+1)}(y-x) = k, \text{ for any } k \text{ in the range of index } G.$$

Features on the same level curves are those with the same level of discrepancy - the level k being their marginal contribution.

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