A procedure to design a structural and measurement model of Intellectual Capital: An exploratory study

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Abstract

An experiment was performed to understand the use of Intellectual Capital in a knowledge-based organization. A theoretical model was created; it interconnects the Intellectual Capital components as a way of understanding the intellectual wealth of a learning organization. Hypotheses were formulated from this. Data were then collected at two different time periods. These were then analysed using two scientific tools: concept mapping and structural equations modeling. Both were found to provide valuable information in studying Intellectual Capital in a knowledge-based firm.

Keywords: Concept mapping; Intangible assets; Intellectual Capital; Partial least squares; University social law department

1. Introduction

For several years, corporate strategy theorists have been paying greater attention to the idea that organisations comprise a body of knowledge. As we move from the Industrial Age into the Information Age, knowledge is becoming a key driver for the competitive success of firms and even nations. Knowledge must be managed effectively in people and organizations to ensure that wealth-creating capacity is maintained [4] and the capacity to manage knowledge is a critical skill [24]. According to Zack [41], the ability to create knowledge and to continue learning from it is a competitive advantage, because innovative knowledge developed today will be core knowledge tomorrow.

However, knowledge is not the only intangible resource and asset of interest to organizations; there is also *Intellectual Capital*, which includes those intangible assets of an organization that are not recorded in financial statements but which may constitute 80% of the market value of the organization [19]. It includes:

- *Human Capital*: the knowledge, skills, etc of individuals;
- *Structural Capital*: the property of the organization, such as processes, information in a database, etc.;
- *Relational Capital*: the relationships that an organisation has with its clients/customers and environment [31,32,14].

The importance of Intellectual Capital was recognized in the Balanced Scorecard [22] and was also embodied in the concept of the learning organisation [1]. Nonaka [29] believed that a learning organization was one that promoted learning among its employees but, more importantly, was an organization that learnt from individual learning; universities are perhaps the prototypical learning organization.

It is important for a learning organization to identify its Intellectual Capital, as it is a key factor to generate future value to the organization [34].

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2. The model development: hypotheses

In order to understand Intellectual Capital in a knowledge-based organization, three models [21,27,39] were first considered. These stated that it first was necessary to identify the mission and strategic goals of the organization and in order to reach its goals, it would be necessary for it to have resources, both tangible and intangible. In the method here, we only consider those intangible assets that allow us to reach our future strategic goals. These assets constitute the Intellectual Capital and they must be assumed to generate value. Finally, we established a series of indicators that allowed us to measure the intangible assets and thus provide input to our structural and measurement model of the Intellectual Capital (see Fig. 1).

To identify the intangible assets, which make up the Intellectual Capital in a knowledge-based organization, we utilized the methodology used to develop Concept Mapping [23,36]. To validate the indicators and the structural model, we used structural equation modeling (SEM).

This led us to three hypotheses to be examined in the study.

Hypothesis 1. Human Capital has a positive effect on Structural Capital.

Human Capital is important, because it is the source of innovation and strategic renovation [6]. Human Capital builds Structural Capital, which can be seen as a consequence of human creativity, similar to that which occurs with financial capital [38]. Structuring intellectual assets could transform the know-how of the individual into a property of the group [28]. The essence of Structural Capital is the knowledge embedded in the routines of the organization [25]. An organization would want to transform most Human Capital into Structural Capital, as it is then owned by the organization.

Hypothesis 2. Structural Capital has a positive effect on Relational Capital.

Some authors are interested in finding out how to use learning to increase Human Capital and hence Structural Capital [33]. By exploring the relationship between Human, Structural, and Financial Capital of a company, Hurbert St. Onge showed that long-range benefits were created by their merging together. *Relational Capital* is defined here as the knowledge embedded in the value chain of the organization; that is to say, the knowledge identified in the relationship of the organization with its suppliers, clients, and entities outside the organization [7]. Human Capital plays a part in the construction of the organizational capital in all businesses and thus interacts to create Relational Capital [16].

Hypothesis 3. Relational Capital has a positive effect on Human Capital.

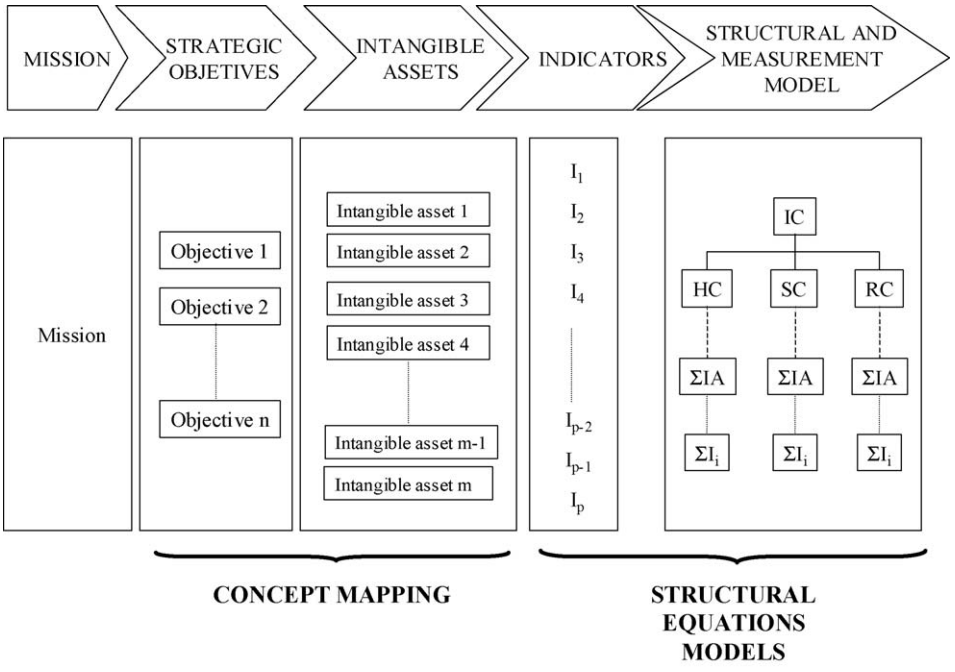

Fig. 1. Research scheme.

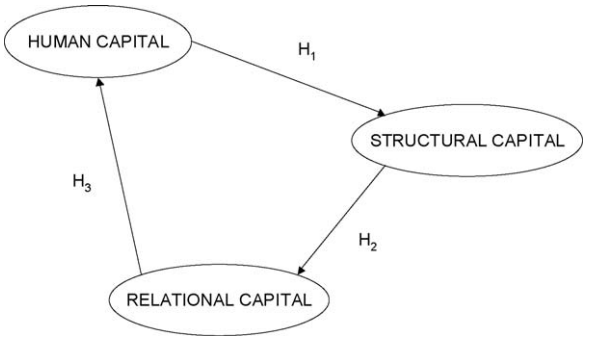

Fig. 2. Hypotheses.

Relational, Client or External Capital is defined as the ability of a business to positively interact with members of the business community to stimulate potential and thus create wealth, which then increases the Human and Structural Capital. The environment of such organizations changes in the same way that relationship with their clients change. The change in environmental factors forces people to develop new abilities, skills, etc., which allow them to adapt to new situations, relationships, etc. [20].

These three hypotheses are represented by the arrows in Fig. 2.

The model proposed here interconnects the Intellectual Capital components as a way to link the intellectual wealth of the learning organization. There is a circular form to the model; that is, a feedback, in which the influence between all the elements is in both directions, directly or indirectly. Human Capital is the immediate precursor to the intellectual wealth of a learning organization. As the knowledge of people who work in the organization is codified (H_1), the Structural Capital assets are used in the relationships and contacts with people outside the organization (H_2). This again results in development of knowledge, abilities, and skills of people (H_3). Thus, since Human Capital is continually developing, the Intellectual Capital increases.

3. Methodology

Our intent was to use a real university system to test our model. The University system normally has a departmental structure, but departments have different values and disciplines. It is thus important to focus on one area. For example, the intangible assets that generate value to a Humanities Department are quite different from those that generate value to a Science Department. As a case study, we focused on the Social Law Department.

Data were collected at times. The first was used to identify the intangible assets in the Department. They were analysed using a concept mapping process. The second set of data was analysed by using SEM to validate the structural and measurement model.

3.1. Concept mapping

This is typically used to develop the conceptual framework that guides an evaluation or plan. It articulates the thoughts and ideas, and their objective representation.

There are six stages in developing a concept map. In the first, the members of the group are selected. They must be experts in the field. At this stage, the focus or major question is decided. In the second stage, brainstorming is carried out to determine factors that affect the question. Then, these items are scored and classified by the members of the group. In the fourth stage, an analysis of the data is carried out: a multidimensional scale is developed, distributing the items in a two-dimensional space. And then a cluster analysis is performed to organize the information into homogeneous groups (clusters maps). In the fifth stage the maps are interpreted and in the final stage they are used for planning and controlling. The maps represent the opinion of the participants.

The reliability of these maps is then verified by analysing the correlation between the different similarity and distance matrices generated in the development process [37].

3.2. Structural equations models

SEM is a multivariate technique that combines aspects of multiple regression and factorial analysis with multiple variables to estimate a series of simultaneously interrelated dependency relationships. The analysis of the SEM can be carried out using one of two techniques: covariance-analysis and partial least squares (PLS).

Intellectual Capital research using PLS is rare, especially if we focus on an analysis of its components. In contrast, a large part of the literature is descriptive and there is a need for consistent research on the relationships that can emerge among the different Intellectual Capital components. Therefore, PLS is a satisfactory technique because it is oriented towards the predictive causal analysis in high-complexity situations, with theoretical knowledge about the relationships which are not well developed [40].

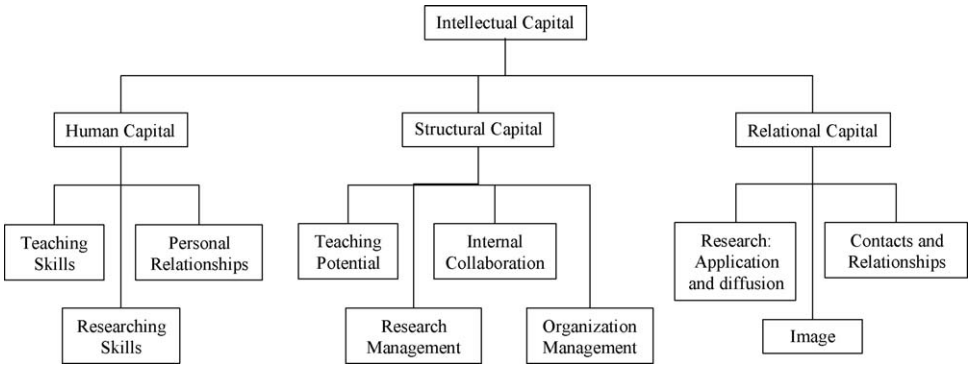

Fig. 3. Intangible assets in a Social Law University Department.

The conceptual core of PLS is an iterative combination of principal component analysis, which links measures with constructs, and path analysis, which allows for building a system of constructs. The hypothesizing of relationships between measures and constructs, and between constructs and other constructs are guided by theory. By using the techniques of ordinary least squares (OLS), estimation of measures and path relationships are carried out. PLS can be interpreted with an understanding of principal component analysis, path analysis, and OLS regression [2].

PLS allows us therefore to contrast the structural and measurement model. The model validity and reliability are analysed by studying the individual reliability of the item and of the constructs, the convergent and discriminant validity, and the statistical significance of parameters.

4. The results

4.1. Mission and strategic goals

The mission of the University is ‘‘the transfer of knowledge and culture; the contribution of the development of society on training as well as on a research or cultural level; that is to say, the diffusion, appreciation and transfer of knowledge to culture, quality of life and economic development’’ [5].

This mission is translated into two goals:

1. Education of professionals.
2. Scientific research and preparation of future researchers.

The departments work autonomously, although they are guided by the mission and goals of the University itself.

4.2. Identification of the intangible assets

The desired outcome, using the technique of developing concept maps, was to identify those intangible assets that comprise the Intellectual Capital of a University department. The information needed to develop this was identified by work groups, who were considered experts at the university; their research and teaching skills had been recognized, as they were involved in education as policy makers, teachers, or researchers [35]. Each participant held a doctoral degree and had passed the Official Government Exam in his or her educational area.

Table 1
Descriptive statistics for reliability estimates for concept mapping projects [37] and reliability estimates for our concept mapping

	r_{II}	r_{IT}	r_{IM}	r_{RR}	r_{SHT}	r_{SHM}
Number of projects	33	33	33	37	33	33
Mean	0.81	0.92	0.86	0.78	0.83	0.55
Median	0.82	0.93	0.86	0.82	0.84	0.55
Minimum	0.67	0.88	0.74	0.42	0.72	0.25
Maximum	0.93	0.97	0.95	0.93	0.93	0.90
S.D.	0.07	0.02	0.04	0.12	0.05	0.15
IC map	0.87	0.95	0.93	0.82	0.77	0.80

Source: Trochim [37] and author.

Table 2
Technical chart

Universe	Departments belonging to Social-Law education at an European University
Geographic range	Local
Information gathering method	Personal survey and secondary data
Sample unit	Department heads and research group leaders
Population census	64
Sample size	59
Sample error	4%
Reliability level	99%; $Z = 2.58$; $p = q = 0.5$
Sample procedure	The survey was directed to the totality of the department heads and to the research group leaders
Date of the field study	The survey was carried out in January and February 2003

Source: carried out by the author.

A total of 14 professors from Social Law departments of a European University participated in the study. There are nineteen departments Social Law area and it has been recommended that the number of participants in this technique should be between 10 and 20 [15].

In the brainstorming session, 60 items that contributed to the strategic goals of the University were identified; subsequently, these were grouped and scored according to their contribution to the strategic goals, giving way to similarity matrices [26]. Finally, the maps were interpreted.

There were 10 clusters in the resulting maps; they represented a set of intangible assets that should help in attaining the strategic goals for a department. These clusters could be grouped into three regions to make up the components of the Intellectual Capital. These clusters are shown in Fig. 3.

In the same way, we identified the relative importance of the three components. To do this [17], we tallied the scores of the clusters, which belonged to each Intellectual Capital components and the relationships between them. Human Capital and Relational Capital were found to be almost equal in importance, but Structural Capital was especially important. This result concurs with that of some authors, who decided that Structural Capital is the most important part of Intellectual Capital because it serves as a vehicle to convert personal knowledge of the employees into value.

The reliability of the maps was determined by comparing the correlations between the similarity and distance matrices. The results fall between the established maximum and minimum values (see Table 1).

4.3. Validation and contrast of the structural and measurement model

For the design of the indicators, our clusters and their associated items were used. In the validation of the

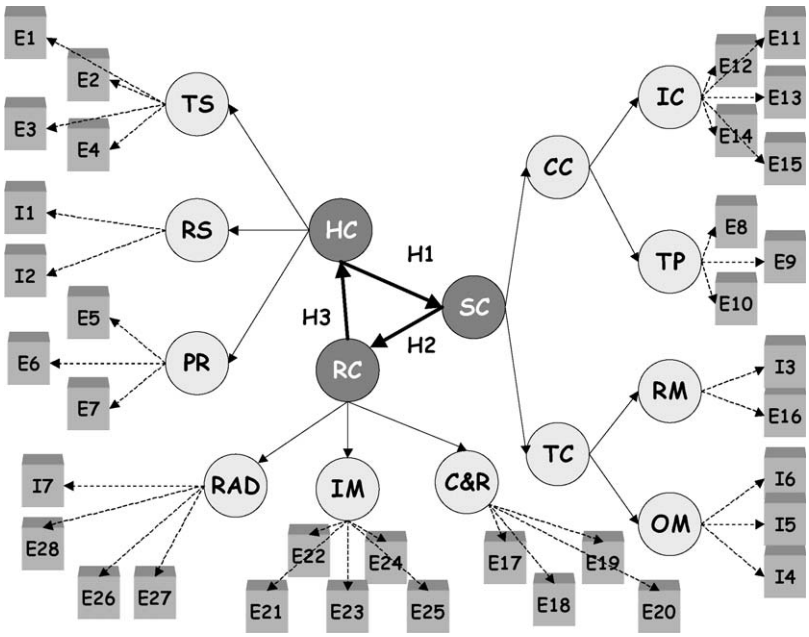

Fig. 4. Structural and measurement model.

measurement model and in the contrast of the structural model we used a PLS program designed by Win Chin [10]. The external validity of a study implies that its results can be applied to the analysis area (the departments belonging to Social Law Education). Therefore, it was essential to validate the representation of the departments and of the sample of the population. Table 2 shows the technical chart of the study.

However, the internal validity of the study demanded that the information had been obtained from appropriate sources. The Chairs of the departments and research group leaders were directly contacted so that they could make available knowledge about the department.

The structural and measurement model were validated as shown in Fig. 4.

Inside the square of indicators, the letter ''E'' is appended if the indicator is subjective and derived from a survey whose items were extracted from the concept maps. An ''I'' is shown if it is an objective indicator adapted from secondary sources, such as the Annual Statistics of the University (see Appendix A for a more detail description of the indicators). Each indicator had been used to measure the intangible assets on the concept map. These intangible assets made up constructs in our model and a circle with their initials inside it represents them (e.g., TS (Teaching Skills), RS (Research Skills), PR (Personal Relationships), etc.). These first order constructs are used to measure the Intellectual Capital components: Human Capital (HC), Structural Capital (SC), and Relational Capital (RC)

Table 3
Statistical highlights

Construct	Composite reliability	AVE	Construct	Load	Composite reliability	AVE	Indicators	Load
HC	0.81	0.59	ST	0.75	0.82	0.53	E1	0.70
							E2	0.70
							E3	0.79
							E4	0.72
			SR	0.64	0.86	0.75	I1	0.87
							I2	0.86
			PR	0.89	0.94	0.86	E5	0.92
							E6	0.93
							E7	0.91
SC	0.72	0.58	TP	0.80	0.82	0.61	E8	0.72
							E9	0.80
							E10	0.81
			IC	0.76	0.93	0.74	E11	0.75
							E12	0.92
							E13	0.89
							E14	0.93
							E15	0.79
			OM	0.73	0.81	0.68	I3	0.83
							E16	0.82
			RM	0.86	0.80	0.57	I4	0.72
							I5	0.86
							I6	0.68
RC	0.82	0.60	C&R	0.87	0.85	0.59	E18	0.81
							E19	0.70
							E20	0.81
							E17	0.72
			IM	0.79	0.89	0.61	E21	0.81
							E22	0.78
							E23	0.80
							E24	0.82
							E25	0.69
			RAD	0.66	0.80	0.50	I7	0.65
							E26	0.75
							E27	0.72
							E28	0.69

Source: carried out by the author.

Table 4
Discriminant validity

	CD	RP	PD	GOI	CIN	GO	IAD	IM	CyR	CI	CO	CT	CH	CE	CR
CD	0.73														
RP	0.622	0.93													
PD	0.305	0.423	0.78												
GOI	−0.190	0.062	0.171	0.76											
CIN	0.241	0.537	0.236	0.048	0.86										
GO	0.018	0.365	0.275	0.030	0.129	0.83									
IAD	0.450	0.484	0.441	−0.007	0.257	0.258	0.71								
IM	0.170	0.444	0.372	0.248	0.464	0.367	0.304	0.79							
CyR	0.214	0.443	0.506	0.327	0.556	0.175	0.444	0.601	0.77						
CI	0.401	0.002	−0.349	−0.435	−0.071	−0.133	0.103	−0.073	−0.258	0.87					
CO											0.83				
CT											0.23	0.78			
CH													0.77		
CE													0.54	0.76	
CR													0.60	0.71	0.77

Source: carried out by the author.

that made up the second order constructs in PLS. They were also represented in a circle with initials. Bold arrows represent the existing relationships between the Intellectual Capital components that formed our hypotheses.

The sample size of 59 was considered large enough for PLS. In general, the most complex regression will involve: (1) the indicators of the most complex formative construct; or (2) the largest number of antecedent constructs leading to an endogenous construct. Sample size requirements become at least ten times the number of predictors in either of these, whichever is greater. There were no formative indicators, so it is the second requirement that must be met. The largest number of antecedent constructs leading to an endogenous construct was thus 50.

By analysing the data and the validity and the consistency of the model, we first found that the validity

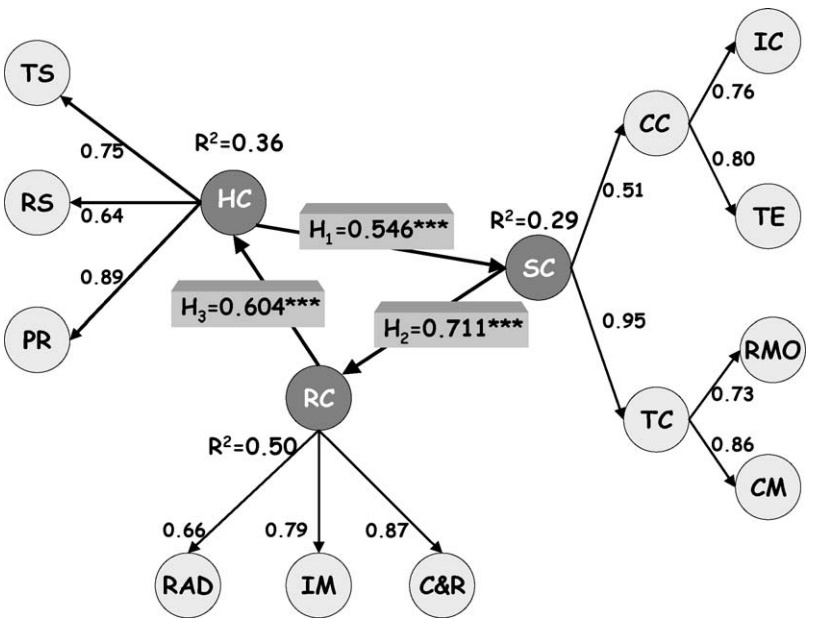

Fig. 5. Results.

of the measurement model, assessed by examining the loading and cross-loadings of indicators, comply with the rule ''more than 0.7'' and thus there is more shared variance between the construct and its measures than error variance [9], with a few exceptions (see Table 3). Loadings of 0.5 or 0.6 may still be acceptable if there are additional indicators in the block for comparison [11]. Once the individual reliabilities had been considered, the composite reliability had to be over 0.7. Convergence validity and discriminant validity were studied. The validity exists when the measurement is strongly and positively correlated with other measurements of the same construct [12] or with the variable with which it should theoretically correlate [13]. We used the Average Variance Extracted (AVE) created by Fornell et al. to observe the convergent validity. AVE is recommended to be greater than 0.5 (see Table 3). Discriminant validity indicated how the two measures are related [3]. By comparing the AVEs with the square of the correlations among constructs this was verified. From Table 4, we see that each indicator loads higher with its respective latent variable. The AVE is shown on the diagonals.

As a second check, the explained variance, R^2, of the Intellectual Capital components was found to be more than 20% in all cases [18], and therefore, it was considered to be at an acceptable level (see Fig. 5).

Finally, to assess the statistical significance of the path coefficients, which are standardized betas, a bootstrap analysis was performed. The use of this as opposed to traditional *t*-tests allowed the testing of the significance of parameter estimates from data that were not assumed to be multivariate normal. Table 5 shows a positive, substantive and significant beta coefficient. Therefore the hypotheses holds true. This supposes a significant contrast of a series of relationships between the different constructs that make up the structural model that represented the theoretical model, all within the frame of SEM.

Table 5
Path coefficients

Hypotheses		Standardised beta coefficient (β)	*t*-Stat (Bootstrap)
H1	Human Capital has a positive incidence over Structural Capital	0.546***	7.35
H2	Structural Capital has a positive incidence over Relational Capital	0.711***	10.54
H3	Relational Capital has a positive incidence over Human Capital	0.604***	8.36

*** Significant at $p < 0.001$.

Table 6
Relative importance of each of the Intellectual Capital components

Intellectual Capital components	Concept maps, %	Partial least square, %
Human Capital	28.6	24.9
Structural Capital	45.7	49.4
Relational Capital	25.7	25.2

Source: carried out by the author.

Furthermore, we obtained the relative importance of each Intellectual Capital components. For this it was enough to tally up the weight given to the different intangible assets after statistically study the data. This showed that Structural Capital was once again the component of greatest importance. Table 6 shows the scores of the Intellectual Capital components from both the concept map and Partial Least Square.

5. Conclusions

We developed and validated a procedure to identify and measure the Intellectual Capital in a knowledge-based organization. This involved identifying the mission and strategic goals of the organization as a means of identifying the intangible assets needed in obtaining those goals via concept maps, which served as a basis for developing a structural and measurement model of the organization's Intellectual Capital, validated by using SEM.

Second, we have identified the intangible assets that make up the Intellectual Capital on Social Law Departments in the University using this procedure. Taking intangible assets lists from previous literature had usually been done to study the Intellectual Capital in the University [30,8]. The main problem of this approach is that the list of intangible assets was based on the personal experience of the authors. They have never been based on the strategic goals of the organization, so they are not adaptable to its particular situation or circumstances. In this research we identified up to ten intangible assets that make up Intellectual Capital in a University Department through concept mapping. A framework this provides a possible answer to the challenge of how to locate new forms of useful knowledge. The intangible assets identified through this technique are compatible with the literature on Intellectual Capital, since its different components (Human, Structural, and Relational Capital) can easily be identified.

Third, the relative importance of each IC components has been proven, and this coincides with the Concept Maps as well as with PLS, arriving to the conclusion that Structural Capital is the most prominent.

Fourth, we validated a structural and measurement model of the Intellectual Capital for a Social Law University Department.

Finally, we observed the positive feedback of the Intellectual Capital components, that is, each one of their components has a positive incidence over the rest, in such a way that a change in any of them will produce an increase in the rest.

Appendix A. Indicators

Teaching skills
- E1 Programmed learning of the departments subjects are updated
- E2 Preparing classes is a value from the culture of the department
- E3 The different programmed learning of the departments subjects are coordinated
- E4 Results derived from researching are made known to everybody in the department through seminars, conferences, etc.

Researching skills
- I1 Percentage of Researching and Teaching Staff (RTS) who has PhD in the department
- I2 Percentage of researching economic complements in the department

Personal relationships
- E5 Personal relationships are good in the department and they generate a good job environment
- E6 There are professional collaboration between people in the department
- E7 There is internal cohesion in the department

Teaching potential
- E8 Teachers from the department has gone to courses, seminars, conferences, etc. in order to improve there formation during the last year
- E9 Teaching innovation can be found in the department by using new technologies (web pages, student help by e-mail, etc.)
- E10 There are subjects manuals (books, problems, cases of study, etc.) to guide students' learning

Research management
- I4 Production of Ph.D.
- I5 Average size of researching groups
- I6 Points given to the researching group by the PAI (Researching Andalusia Plan)

Internal collaboration
- E11 Criteria for selecting people, for internal promotion, etc. are stable and known by everybody in the department
- E12 The number of Departments Meetings celebrated in a year are good
- E13 Departments commissions are operatives
- E14 The results arrive by the departments commissions are made known to everyone in the department and they are support by the department directorate
- E15 Information of general interest is accessible to everyone in the department

Organization management
- E16 The department directorate encourage relationships through extra-departmental activities (informal meetings, launch, etc.)
- I3 Department financiering

Contacts and relationships
- E17 The department collaborates in organizations of congress, seminars, conferences, courses, etc.
- E18 The department collaborates with other university departments
- E19 The department collaborates with other private entities [firms, NGO (no governmental organizations), etc]
- E20 The department collaborates with other public entities different from the university

Image
- E21 The department is concerned with showing a uniform corporative image
- E22 How much information do you have about the image of the department *in* the Faculty?
- E23 The image of the department *in* the Faculty is good
- E24 How much information do you have about the image of the department *outside* the Faculty?
- E25 The image of the department *outside* the Faculty is good

Researching: application and diffusion
- E26 Teachers in the department goes to researching seminars, congress, courses, meetings, etc. annually
- E27 Someone in the department makes an stay in other centre as a visitor professor (or similar) during four months at least
- E28 Courses included into the doctorate programmed learning fit with the basic researching lines in the department
- I7 Average number of publications in the department

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