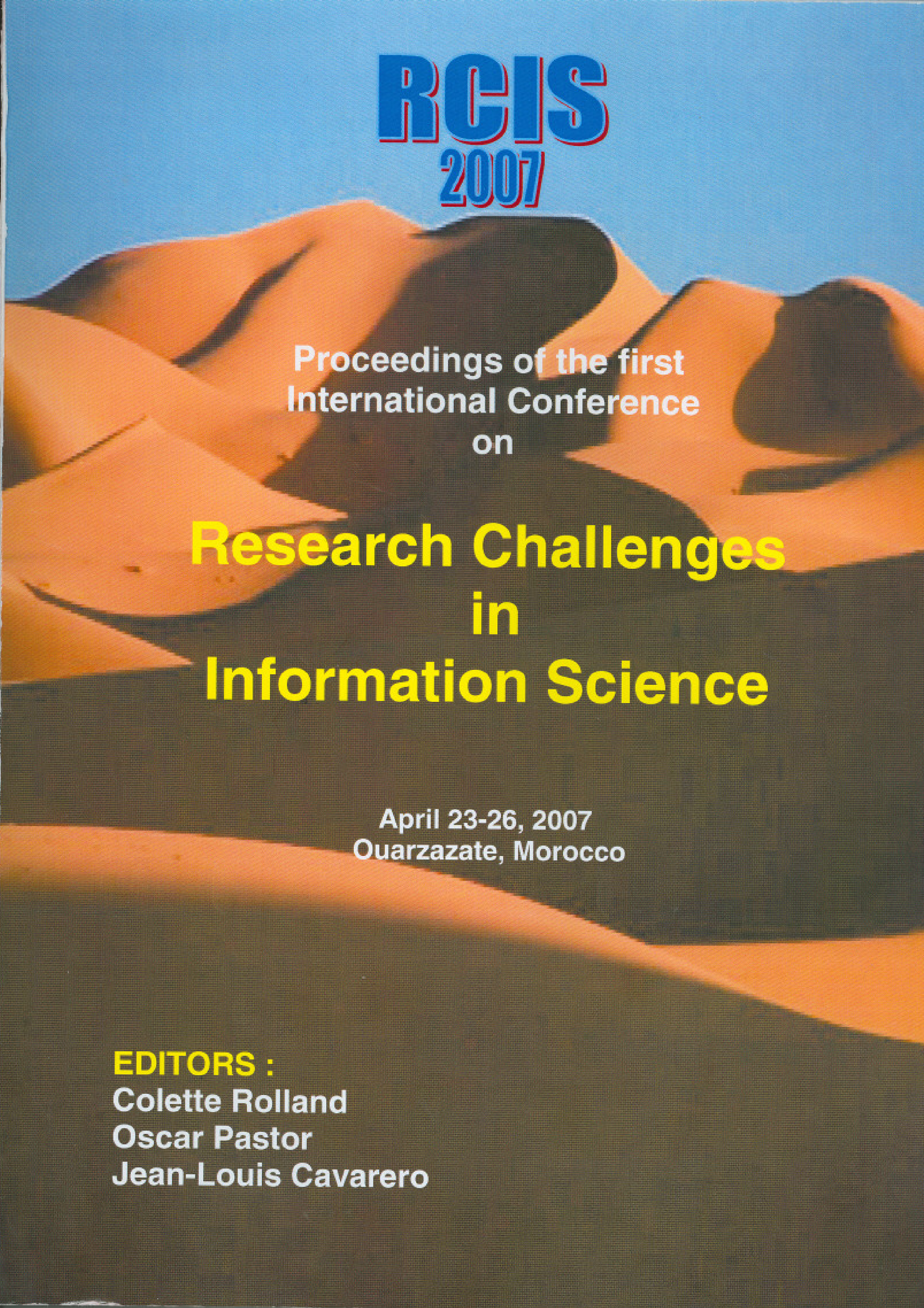

RCIS 2007

Proceedings of the first International Conference on

Research Challenges in Information Science

April 23-26, 2007
Ouarzazate, Morocco

EDITORS :
Colette Rolland
Oscar Pastor
Jean-Louis Cavarero

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We wish to thank the following organisations for their contribution to the success of this Conference.

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WELCOME MESSAGE FROM THE CHAIRS

Welcome to the First International Conference on Research Challenges in Information Science –RCIS'07-.

It is a big pleasure for all of us to celebrate this first edition of RCIS, which aims at providing an international forum for scientists, researchers, engineers and developers from a wide range of information science areas to exchange ideas and approaches in this evolving field. To make it possible, a lot of people have done a hard work. It would impossible to name all of them, but we want to especially thank all the organizers, their efforts to make this conference become a reality. Of course, we also want to thank all the Program Committee Members, their involvement in the evaluation of all the submitted papers. It is always a complicated work to select only a subset of the submitted works, but with the help of our PC members we have been able to prepare a –hopefully!- exciting scientific program, that properly complements the exciting site selected for celebrating this conference.

Yes, this is the first edition, but we have had the impressive number of 103 submitted papers. To keep the required level of quality, and after having at least three reviews for paper, only 31 long papers and 17 short papers were accepted. Additionally, 5 doctoral papers and 11 poster submissions were accepted.

All that together allow us to conclude that the offer for the participants has really a high-level, that is properly complemented with our reputated keynote speakers, **Klaus Dittrich** (University of Zurich), **Kalle Lyytinen** (Case Western Reserve University), **Barbara Pernici** (Politecnico di Milano), and **Arne Solvberg** (The

Norwegian University of Science and Technology). Thanks to all of them for sharing this event with us. There are not too many options for listening to all of them together in a common event. This is for sure a strong added value for this first edition of RCIS.

Ouarzazate is doing the rest: a beautiful place to enjoy such a promising conference. Again thank you very much to all the local organizers for making easier to solve any problem. RCIS 2007 would not have been possible without the efforts of all of them, who selflessly offered their time and energy to make this conference a success.

It is time now to enjoy the conference, to enjoy Ouarzazate, and to be ready for pushing a second successful of RCIS next year. Thanks to everybody!

Colette Rolland, Oscar Pastor, Jean Louis Cavarero

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An Exploratory Experiment to Validate Measures for Business Process Models

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***Abstract*—Within the setting of an organization where there is ongoing improvement, the business processes call for frequent changes in which all the stages of the life cycle of the process are clearly affected, particularly so the modelling or design stage. This phase is of special significance, as it is used as the basis for an understanding and carrying out the processes later.**

Taking as our goal the improvement of business processes, in this piece of work we put forward a set of measures for assessing the structural complexity of conceptual models of business processes. The aim is to obtain useful indicators for when we are carrying out maintenance tasks on the models. It is also to enable an early evaluation of given quality properties of the model. It is with all this in mind that the validation of the proposed measures was performed by means of an empirical study. This made it possible to find out the set of measures that are useful for evaluating the usability and maintainability of conceptual models of business processes.

***Keywords*—Business process models, BPMN, Measures, Empirical validation.**

I. Introduction

The modelling of business processes is one of the first steps in the achieving of organizational goals. Its objectives, business-wise, fit into different categories as regards the different aspects they possess two of these categories stand out in particular [1]: a) Improving the understanding of a situation and communicating it among the different *stakeholders* and *b)* Using them as a tool in reaching the goals of a project of process development. Apart from all the above and as regards systems, business process modelling is considered to be an essential part of any software development project, allowing the analyst to capture the scheme and the general procedures which direct and guide the business [2].

Alongside the clear objectives that already exist from both the business and system viewpoint, other aspects appear which the business process models must tackle: these are no less important than those features already mentioned. It is our firm conviction that, just as the process maintenance phase is important in the area of software engineering, the same importance should be afforded in the case of business process modelling.

Over the last ten years, firms have found themselves being caught up in commercial environments of competitiveness and of constant change, both internally and externally. So they often have to update or modify their processes. This movement of organizations towards ongoing improvement is known as the BPR *(Business Process Re-enginering)* initiative, as proposed by Hammer and Champy in the 90´s [3]. At present, and thanks to the resource known as BPM (Business Process Management) that has been growing in popularity over the last few years, all the phases of the process life-cycle are being included, thus bringing together management theory and new technology [4].

Our own interest focuses on the process design stage, where the visualisation of the tasks carried out in the organization is made possible. This phase refers to the modelling, handling and redesigning of processes, but when maintenance tasks must be performed the stage can be rather complicated. It implies a heavy investment of time and resources, since it involves both technical developers and business analysts.

Bearing in mind all those factors, our work has as its main focus of attention the assessment of the structural complexity of business process models at a conceptual level. In doing so, what we have aimed to do is to give support to business process management, allowing an early evaluation of certain quality properties of the models. It also makes the evolution of process models possible, providing as it does objective information about maintainability, especially in those organizations which have given themselves over to ongoing improvement.

Our starting point for this study was the definition of measures for business process models expressed by the standard notation of BPMN *(Business Process Modeling Notation)* [5]. To validate the proposed measures, a family of experiments is being carried out at present in a population made up of experts in business analysis and software engineering. This will allow us to compare the results of both types of profiles.

In this paper we present the obtained results in the first experiment of the family. The paper proceeds as follows: in section 2 a summary is given of the related works for the evaluation and measurement of business processes. The measures that we have defined are set out in section 3 and under the 4th heading different aspects of the first experiment carried out are described. In sections 5 and 6 an analysis of the results obtained from the data collected in that experiment and the validity threats are shown. Finally, in the 7th section we put forward our conclusions, along with work proposed for the future.

II. Related Work

Little can be found in the literature related to measurement and assessment of business process (BP), at least at a conceptual level, which is the main theme of our study. The studies found in the literature and which are related to the evaluation of business processes focus mainly on an analysis from the point of view of their execution

Thus Powell *et al.* [6], by means of the measurement and control of business processes, seek to identify control mechanisms for business processes that are effective in different types of environments.

Other studies that are also interesting are, for example, those by Tjaden *et al.* [7] who define three metrics for measuring the structural effectiveness of the business processes, which he called of complexity, integration, and dynamism, based on the idea that, to be able to predict performance before a new process is implemented, the management needs structural metrics which will analyse the most static properties of business processes.

On the other hand, Vitolins [8], proposes a new methodology for the definition of business processes measures based on a measurement metamodel, with the objective of providing new possibilities for business process measurement, decreasing the gap between technical solutions and asset management methodologies. In [9] a collection of complexity metrics for business process models is presented, which were found in the pertinent literature is set out- these were compared to a set of given criteria.

Studies do exist about the evaluation of the quality of techniques for business processes modelling, such as in [10, 11] where they propose a framework divided into two parts: in the way of modelling and the way of working of a modelling technique. The objective of the study was to provide a set of well-defined properties, along with a series of procedures for giving an objective measurement of these properties.

A recent work on measures of complexity for business process models is that presented by Gruhn and Laue [12], where they discuss how ideas that are already a familiar part of research on software complexity might be used to analyse the complexity of business process models. They start from the idea that when the cognitive weight of the business process model is measured, information about how easy or how difficult it is to understand the model is obtained. They then give a cognitive weight to the business process model elements, going on then to determine the cognitive weight of the model as a whole.

III. Measures For Business Process Models

To assess the complexity of business process models, a representative set of measurements has been defined in this work. Our interest lies in evaluating the complexity of business processes by starting from the model which represents them at a conceptual level, and in order to do this we have used BPMN [5], this being the most recent specific standard notation for business process modelling. BPMN provides a graphic notation for expressing business processes through a Business Process Diagram (BPD) which is composed of two categories of basic elements with which it is possible to develop both simple and high level models.

Our work proposes an adaptation and extension of the proposal FMESP (Framework for the Modeling and Evaluation of Software Processes) [13] to business processes. To get an objective knowledge of the external quality of business process models (BPMs) we have defined a set of measures to evaluate the business process models represented with BPMN. The terms used in this work as regards the measurement of business process models are based on the Software Measurement Ontology defined by García *et al*. [14]. Likewise, we have defined a set of measures for models represented with BPMN and these have been placed in two categories: base measures and derived measures.

The base measures consist principally of counting the business process model’s significant elements and a total of 46 base measures have been defined according to the main elements of which the BPMN metamodel is composed. These are distributed, in accordance with the four categories of elements, in the following way: 37 base measures correspond with the *Flow Objects* category, 5 with the *Connecting Objects* category, 2 with the *Swimlanes* category and 2 with the *Artefacts* category.

With the definition of these base measures, it is possible to discover how many significant elements there are in the business process diagram. Nevertheless, starting from the base measures shown previously, a set of derived measures has been defined which allows us to see the proportions that exist between the different elements of the model. The set of derived measures defined according to the base measures is shown in Table I.

The main aim of the definition of the base and derived measures, it is to evaluate the structural complexity of business process models developed with BPMN. In this way, when we analyse the model structurally, it is also possible for us to evaluate its internal quality.

TABLE I
DERIVED MEASURES

Measure	Definition
TNSE	Total Number of Start Events of the Model TNSE = NSNE+NSTE+NSMsE+NSRE +NSLE+NSMuE
TNIE	Total Number of Intermediate Events of the Model TNIE = NINE+NITE+NIMsE+NIEE +NICaE+NICoE+NIRE+NILE+NIMuE
TNEE	Total Number of End Events of the Model TNEE = NENE+NEMsE+NEEE+ NECaE+NECoE+NELE+NEMuE+NETE
TNT	Total Number of Task of the Model TNT = NT+NTL+NTMI+NTC
TNCS	Total Number of Collapsed Sub-Process of the Model TNCS = NCS+NCSL+NCSMI+NCSC+NCSA
TNE	Total Number of Events of the Model TNE = TNSE + TNIE + TNEE
TNG	Total Number of Gateways of the Model TNG = NEDDB+NEDEB+NID+NCD+NPF
TNDO	Total Number of Data Objects in the Process Model TNDO = NDOIn + NDOOut
CLA	Connectivity level between Activities $CLA = \frac{TNT}{NS}$
CLP	Connectivity Level Between Pools $CLP = \frac{NMF}{NP}$
PDOPIn	Proportion of Data Object like Incoming Product and the total of Data Objects $PDOPIn = \frac{NDOIn}{TNDO}$
PDOPOut	Proportion of Data Object like Outgoing Product and the total of Data Objects $PDOPOut = \frac{NDOOut}{TNDO}$
PDOTOut	Proportion of Data Object like Outgoing Product of Activities of the Model $PDOTOut = \frac{NDOOut}{TNT}$
PLT	Proportion of Pools and/or Lanes of the Process and Activities in the Model $PLT = \frac{NL}{TNT}$

The defined measures have been theoretically validated according to the Briand *et al*. theoretical framework [15]. As a result, it has been possible to group them in relation to the different properties of structural complexity they evaluate (Fig. 1).

Once the theoretical validation has been performed, our objective is to find which of the defined measures can provide useful and objective information about the external quality of the BPMs.

Namely, we will focus on two characteristics of the ISO 9126 external quality: Usability and Maintainability which will be evaluated by means of the sub-characteristics understandability and modifiability, respectively. To achieve this goal a family of experiments is taking place. The first experiment of this family is described in the following section.

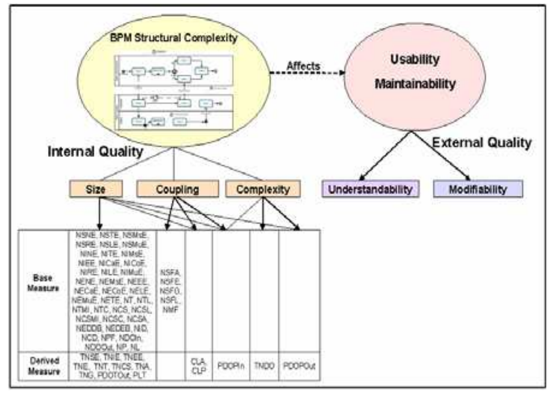

Fig. 1. Relationship between structural complexity and quality attributes.

IV. FIRST EXPERIMENT

In order to establish which measures are useful in evaluating the understandability and modifiability of BPMs, a family of experiments has begun to be developed and this will in turn allow us to assess quality aspects of business process conceptual models expressed in BPMN.

Given the quantity of measures proposed, and in an attempt to choose a representative set of these, an empirical validation of the measurements has been carried out in line with the suggestions of Perry *et al*. [16], Wholin *et al*. [17], Juristo and Moreno [18], Ciolkowski *et al*. [19] and Briand *et al*. [20].

A. Research Objectives

Using the GQM template (Goal Question Metric) [21], the goal of the experiment is defined as: To *analyse* measures of BPM structural complexity, *with the purpose of* evaluating them *as regards* their capability of being used as indicators of business process model understandability and modifiability. The last two features will be assessed by the researchers *in the context of* PhD students, research assistants and lecturers in software engineering.

B. Participants

The participant group was made up of 27 subjects, consisting of doctorate students, research assistants and lecturers in the Computer Engineering School of the University of Castilla-La Mancha in Spain.

The subjects were chosen as suited our purposes and all of them had a broad knowledge of the modelling of the product (UML, data bases, etc). But they had no previous experience of the conceptual modelling of business processes, so were given a preparatory lesson before the experiment was carried out.

In this session they received an explanation of the BPMN standard notation for the modelling of business processes. Nevertheless, although they took part in this training session, our subjects were not made aware of the aspects that we were attempting to study.

C. Material

The material consisted of ten BPMs represented with BPMN, which had different structural characteristics and dimensions from each other; that is to say, models with different degrees of complexity were selected. These had been obtained by varying the value of the measures in each model, as can be seen in Tables II and III. Our intention, on choosing models with different dimensions, is to determine the influence of the complexity of the model for different subjects such as business analysts and software engineers, who are the main focus of our study.

Moreover, two questionnaires were formulated for each of the aforementioned models, the first of which consisted of a series of questions related to the model's understandability, and the second of which proposed a series of modifications to be carried out in the model, such as evaluating the complexity of the process models presented. In addition to that, at the end of each questionnaire a question was included, whereby the subjects were to assess subjectively the complexity of the models presented. The material also included an example of a solution which showed how the exercises should be done. An example of the material used in the experiment is displayed in Appendix A.

TABLE II
VALUES OF BASE MEASURE

BPM	BASE MEASURES VALUE																						
	NSNE	NSMsE	NITE	NIMsE	NICoE	NENE	NEMsE	NECoE	NT	NTL	NCS	NEDDB	NEDEB	NPF	NSFA	NSFE	NSFG	NSFL	NMF	NP	NL	NDOIn	NDOOut
1	2	0	0	0	0	2	0	0	9	0	0	1	0	0	6	2	2	0	2	2	0	1	2
2	2	0	0	0	0	2	0	0	6	0	0	1	0	0	2	2	2	0	3	2	0	2	0
3	2	0	0	0	0	4	0	0	10	0	0	1	0	0	4	2	6	1	5	2	0	3	3
4	1	0	0	0	0	1	0	0	5	0	2	2	2	0	1	1	8	0	2	2	0	0	2
5	3	0	0	2	0	1	2	0	9	0	2	3	0	1	7	3	7	0	1	2	0	14	8
6	1	1	0	1	3	1	1	1	9	0	0	3	0	0	0	9	6	0	12	5	0	1	1
7	1	1	1	1	2	6	1	1	15	2	3	3	1	0	7	6	11	1	3	3	0	0	2
8	3	0	0	0	0	3	0	0	20	0	0	1	0	0	16	3	2	0	0	3	0	2	2
9	3	0	0	0	0	4	0	0	27	0	0	1	0	0	20	3	2	0	12	3	2	2	2
10	3	0	0	0	0	9	0	0	32	0	0	3	3	0	15	3	14	2	16	3	0	2	3

TABLE III
VALUES OF DERIVED MEASURES

BPM	DERIVED MEASURE VALUE														
	TNSE	TNIE	TNEE	TNE	TNT	TNCS	TNA	TNG	TNDO	CLA	CLP	PDOPIn	PDOPOut	PDOTOut	PLT
1	2	0	2	4	9	0	9	1	3	1,5000	1,0000	0,3333	0,6667	0,2222	0,0000
2	2	0	2	4	6	0	6	1	2	3,0000	1,5000	1,0000	0,0000	0,0000	0,0000
3	2	0	4	6	10	0	10	1	6	2,5000	2,5000	0,5000	0,5000	0,3000	0,0000
4	1	0	1	2	5	2	7	4	2	7,0000	1,0000	0,0000	1,0000	0,4000	0,0000
5	3	2	3	8	9	2	11	4	22	1,5714	0,5000	0,6364	0,3636	0,8889	0,0000
6	2	4	3	9	9	0	9	3	2	0,0000	2,4000	0,5000	0,5000	0,1111	0,0000
7	2	4	8	14	17	3	20	4	2	2,8571	1,0000	0,0000	1,0000	0,1176	0,0000
8	3	0	3	6	20	0	20	1	4	1,2500	0,0000	0,5000	0,5000	0,1000	0,0000
9	3	0	4	7	27	0	27	1	4	1,3500	4,0000	0,5000	0,5000	0,0741	0,0741
10	3	0	9	12	32	0	32	6	5	2,1333	5,3333	0,4000	0,6000	0,0938	0,0000

The material was arranged into two groups (X and Y): group X consisted of ten BPMs, of which five models had a questionnaire relating to the model's understandability and the other five had a questionnaire relating to the model's modifiability. Group Y was made up of the same ten models as the first set, but with the questionnaires the other way round; in other words the first five models corresponded to a questionnaire relating to the model's modifiability, and the remaining five to the model's understandability.

D. Experimental Design

A within-subjects design was carried out, in which all the subjects had to answer all the tests. The ten business process models which were handed out to each subject were given in a different order in each case. While the material described was being given out to the subjects, there was a brief explanation of how to fill in the test-they were told that there was no time limit for the completion of this. They were encouraged to ask the person in charge of the organization of the experiment about any doubts they might have. An overview of the design of the experiment can be seen in Fig. 2.

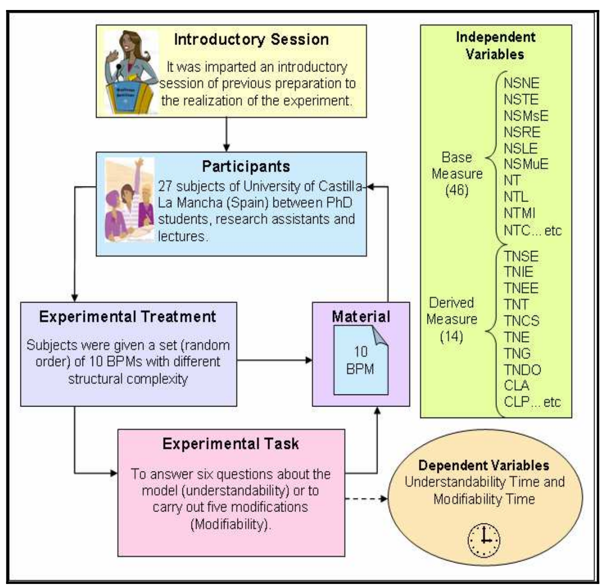

Fig. 2. Experimental Design

Apart from the introductory session about business process modelling with BPMN, the students were given, together with the material for the experiment itself, a guide to BPMN notation and two exercises with corresponding answers, for each one of the two questionnaires that made up the experiment

E. Experimental Task

Each subject received material composed of ten BPMs (five with understandability questions and five with modification requests). Depending on the model (group X or Y) the subjects had to do one of the following tasks: to answer "yes" or "no" to six questions about the model or to carry out five modifications consisting of adding and/or deleting activities, data objects, roles or dependences among these elements.

The tasks of each type (understandability or modifiability) to develop were similar in complexity, this being a basic feature that was borne in mind when the material was being put together. For this reason, the only source of variation when performing tasks of the same type was to be the complexity of each model. Before starting to perform the tasks required in each model the subjects had to write down the starting time: they were to write down the finishing time at the end of the task.

Finally, the subjects were asked to give a subjective assessment of the overall complexity of the model as they had experienced it. To do that they had available a scale of 1-5, with linguistic values attached (1= very simple, to 5= very complex). Five linguistic labels were chosen because we believed that these were sufficient to cover all the possible categories for each sub-characteristic to be evaluated, as recommended by Godo *et al*. [22] and Bonissone [23] for when an uneven number of labels is chosen.

F. Variables

The independent variables correspond to the proposed measures, that is to say the base measures and derived measures already described. The dependent variables are those relating to the understandability and modifiability of the BPMs, which will be measured according to the time subjects employed to solve the understandability and modifiability tasks. They will also be measured according to the success rate in the questions relating to the understandability tasks, the success rate in the modifications of the tasks and the subjective rating with respect to complexity.

G. Hypotheses

The hypotheses proposed with respect to the objective of our investigation are the following:

- Null hypothesis, H_{0u}: There is no significant correlation between the structural complexity measures and the understandability.
- Alternative hypothesis, H_{1u}: There is a significant correlation between the structural complexity measures and the understandability.
- Null hypothesis, H_{0m}: There is no significant correlation between the structural complexity measures and the modifiability.
- Alternative hypothesis, H_{1m}: There is a significant correlation between the structural complexity measures and the modifiability.

V. Analysis of the results of the first experiment

To validate the results, once these were collected from the answer sheets, we ensured that these sheets had been completely filled in and that the correct answers were checked off, along with the different times used to do each exercise.

When carrying out the analysis and interpretation of the data collected, we tried to test the hypotheses posited in section 4.7 and to that end a summary of this data was made. This summary is made up of the values of the measures for each business process model (as seen in tables 2 and 3), as well as the mean values of the marks given by the subjects for both of the sub-characteristics analysed and the average time of understandability and modifiability (Table IV).

As can be seen in Table 4, models 5, 6 and 10 were the most difficult for the subjects to understand, while models 2, 7 and 9 turned out to be more complex when carrying out maintenance tasks, in this case this refers to tasks to perform the requested modifications. On analysing the values of the standard deviation, it can be observed that there is a variation, since models 6, 8 and 10 show a higher standard deviation for understandability, whereas models 1, 2 and 5 are the ones which show a greater standard deviation for modifiability tasks.

TABLE IV
MEAN VALUES AND STANDARD DEVIATION FOR UNDERSTANDABILITY AND MODIFIABILITY TIMES

BPM	Und. Time		Modifiability Time	
	Mean	Std.	Mean	Std.
1	121	43	327	172
2	166	42	401	193
3	185	53	291	106
4	149	57	306	127
5	280	80	375	160
6	279	130	345	143
7	221	75	416	102
8	211	83	305	77
9	187	58	392	106
10	238	98	319	107

When we analyse these results and if we take into account the values of the measures presented in Tables II and III, models 7, 9 and 10 seem to be the models which have the highest level of structural complexity. This provides us with some evidence about the influence of the structural complexity of business process models in their maintainability.

As regards the results of the subjective assessment that the subjects were asked to carry out about the complexity of the models presented, these are summarised in Table V. If we analyse the median value of the data coming from the subjective assessment of the subjects, it can be seen that using the scale given, subjects saw understandability as being at a normal level of complexity in the case of almost all the models. The exceptions to this were in the cases of models 2, 3 and 4, which were given the complexity qualification of "rather simple".

TABLE V
SUBJECTIVE ASSESSMENT OF THE COMPLEXITY OF THE MODELS

BPM	Und. Value.	Mod. Value
1	3,00	3,00
2	2,00	2,00
3	2,00	3,00
4	2,00	2,00
5	3,00	3,00
6	3,00	3,00
7	3,00	4,00
8	3,00	3,00
9	3,00	3,00
10	3,00	3,50

In the case of the subjective assessment of the models where modification tasks were to be performed, models 7 and 10 received a higher grade in the assessment of complexity, being classified as "rather complex". The rest of the models were assessed as being of "rather simple" or "normal" levels of complexity.

Comparing these results with the times related to the tasks of understandability and modifiability, models 7 and 10 get similar results to each other. They are amongst the models which show a greater degree of complexity.

We could further point out that, using the summary of averages in understandability and modifiability times, as well as the summary of values of the measurements, it was possible to carry out a statistical analysis. To see if the data distribution was normal, the Kolmogorov-Smirnov test was applied. The findings were that it was not normal, so it was decided to use a non-parametric statistical test such as Spearman's coefficient of rank correlation, with a level of significance of $\alpha = 0.05$. This indicates the possibility of rejecting the null hypothesis when it is true (type I error), in other words, the confidence level is 95%. Using the Spearman coefficient, each one of the measures was correlated separately with the times for understandability and modifiability. In Table VI the results of the analysis of correlation for the times of understandability and modifiability and the correct answers in the tasks of understandability and modifiability are shown, along with the subjective assessment of the subjects in both exercises.

As can be seen in Table VI, there exists a correlation (rejecting the H_{0u} hypothesis) between the times of understandability and the following measurements: NIMsE, NEMsE, NEDDB, NSFE, TNIE and TNE. Nevertheless, as regards the time used by subjects in the modifiability of the diagrams, the analysis of correlation gave no result (accepting the H_{0m} hypothesis). So no measure correlates with that variable. Bearing in mind that there is no correlation of the defined measures as regards modifiability times, in future experiments this aspect will be taken into account when it comes to fine-tuning the material for the experiment.

TABLE VI
RESULTS OF THE ANALYSIS OF SPEARMAN'S CORRELATION

Measure	UndT	ModT	UndS	ModS	UndVs	ModVs
NIMsE	,742(*) 0,014	0,472 0,168	-0,35 0,321	-0,373 0,288	0,423 0,224	0,343 0,332
NENE	0,049 0,892	0,025 0,946	0,491 0,15	-0,242 0,5	0,193 0,592	,691(*) 0,027
NEMsE	,742(*) 0,014	0,472 0,168	-0,35 0,321	-0,373 0,288	0,423 0,224	0,343 0,332
NT	0,387 0,27	-0,067 0,853	,636(*) 0,048	-0,562 0,091	0,577 0,081	,756(*) 0,011
NEDDB	,744(*) 0,014	0,268 0,454	-0,216 0,549	-0,374 0,287	0,378 0,282	0,485 0,155
NSFA	0,231 0,521	0,073 0,841	,737(*) 0,015	-0,431 0,213	0,572 0,084	0,512 0,13
NSFE	,824(**) 0,003	0,405 0,245	0,252 0,483	-0,484 0,156	,754(*) 0,012	,677(*) 0,031
NSFL	0,225 0,532	-0,135 0,71	-0,023 0,951	-0,384 0,273	0 1	,699(*) 0,025
NDOIn	0,315 0,376	-0,201 0,577	0,06 0,869	-,687(*) 0,028	-0,039 0,914	-0,036 0,922
NDOOut	0,331 0,35	-0,376 0,284	-0,15 0,679	-,708(*) 0,022	0,163 0,653	0,415 0,234
TNSE	0,563 0,09	0,04 0,912	,657(*) 0,039	-,728(*) 0,017	0,63 0,051	0,421 0,226
TNIE	,682(*) 0,03	0,502 0,139	-0,328 0,355	-0,23 0,523	0,423 0,224	0,419 0,228
TNEE	0,556 0,095	0,099 0,786	0,304 0,393	-0,609 0,062	0,426 0,22	,859(**) 0,001
TNE	,835(**) 0,003	0,366 0,298	0,196 0,587	-0,607 0,063	,650(*) 0,042	,862(**) 0,001
TNT	0,387 0,27	-0,067 0,853	,636(*) 0,048	-0,562 0,091	0,577 0,081	,756(*) 0,011
TNA	0,512 0,13	0 1	0,571 0,085	-0,626 0,053	,650(*) 0,042	,783(**) 0,007
TNDO	0,332 0,348	-0,395 0,258	0,069 0,849	-,805(**) 0,005	0,197 0,586	0,273 0,445
CLA	-0,406 0,244	0,103 0,777	-0,366 0,298	0,433 0,211	-,722(*) 0,018	-0,26 0,467
PDOTOut	0,03 0,934	-0,333 0,347	-,768(**) 0,009	-0,152 0,674	-0,114 0,754	-0,034 0,925

As far as the correct answers in the understandability and modifiability tasks are concerned, there is a correlation between the correct understandability responses and the NT, NSFA, TNSE, TNT and PDOTOut measures. So too, a correlation appears between the right answers in the modification exercises and the following measurements: NDOIn, NDOOut, TNSE and TNDO.

Finally, with regard to the subjective assessments which the subjects gave of the models, there is a correlation between understandability and the NSFE, TNE, TNA and CLA measurements, as well as a correlation between modifiability and the following measurements: NENE, NT, NSFE, NSFL, TNEE, TNE, TNT and TNA. The summary of this analysis is that the measures which show two or more correlations with the variables analysed are these: NT, NSFE, TNSE, TNE, TNT and TNA.

VI. VALIDITY THREATS

The main issues that threaten the validity of the empirical study were:

- **Internal Validity**. The following variables were controlled as part of the experiment:
  - *Participant characteristics*: the use of a within-subjects design minimized the possible threat of differences among subjects.

- *Task complexity*: the experimental tasks were equivalent in complexity for each group of experimental models (understandability and modifiability).
- *Instrumentation*: the same measurement techniques were used for independent and dependent variables for all participants. The risk of measurement error was reduced by calculating the values for all variables automatically.
- *Training*: all participants were given the same prior training session and they received the background necessary to carry out the experiment properly.
- *Learning effects*: experimental models were given to subjects in random order and only one type of task (understanding or modification) was required for each model, so as to minimize learning and sequence effects.
- *Control of environment*: This fact did not affect the internal validity because the replicas were conducted under controlled conditions, the participants being supervised by the conductors of the experiment in the classroom.
- *Fatigue Effects*: The average duration of the replicas was of forty minutes and so fatigue effects were avoided.
- *Measurement error*: Another threat to internal validity is the fact that subjects were responsible for recording the time it took to perform the experimental tasks. This increases the risk of measurement error for the dependent variable, as subjects could have recorded the time inaccurately. The within-subject design helped to minimize this threat because the possible measurement error should be randomly distributed across levels of the independent variable. Besides, a digital clock was displayed during the execution of the experiment to make it easier for participants to write down accurate times.

- **External Validity**. We identify three possible threats to the external validity of this study:
  - *Experimental models*: In the experiment, we have used example business process models found in the literature, as well as tasks which are representative of real cases. But more studies of an empirical nature, using real business process models from companies, must be carried out.
  - *Experimental task*: The types of task to perform on the models were designed to accomplish the goals of the research and they should be adapted to situations in practice. With respect to the environment, the experiment was done using pen and paper. In future experiments, we could consider the use of software tools to perform the activities required, in order to provide a more realistic environment.
  - *Sample population*: A clear threat to the generality of the findings of this study was the type of experimental subjects. The population selected was not made up of professionals, which reduces the possibility of generalizing the results in practice. This threat will, we trust, be diminished in the future, when new empirical studies take place in a population made up of people from the realm of business.

VII. Conclusions and Further Work

It is recommendable to analyse the structural complexity of BPMs as a starting point in their evaluation, as well as in carrying out maintenance tasks. The design, assessment and maintenance of BPMs involve various different spheres. It is thus a topic that has generated interest, not only on the part of people in the business world, but also on the part of those involved in the area of software engineering.

In this paper, a set of measures has been presented, whose definition based on the BPMN Standard has as its objective the analysis and evaluation of business process models at a conceptual level. Another aim in a similar vein is to analyse quality attributes of the model, such as usability and maintainability. In this sense, the support needed when carrying out maintenance of BPMs would be made available.

In addition to what we have just outlined in the above paragraph, the results of an initial experiment performed on PhD students, research assistants and lecturers in the Faculty of Computer Engineering in the University of Castilla-La Mancha have been presented. This first study made it possible to find out that, out of the total body of measures defined, six of them correlate with times of understanding, eight have a correlation with the correct responses of understanding and modification and nine measures have a correlation with the subjective assessment about the complexity of the models.

On similar lines, it was possible to know that, out of the measurements defined, none of them correlate with the modifiability times of the models. Given that this is so, the material for the experiment will need to be fine-tuned so that it can provide us with information related to that variable.

As far as work to be undertaken is concerned, the following aspects are to be tackled:

- To confirm the results of the initial experiment, a replica will be performed in the Autonomous University of Tamaulipas (Mexico), with students of a Master's course in Information Systems. This is being taught in the Division of Postgraduate Studies and Research in the Arturo Narro Siller Faculty of Engineering.
- To conduct new experiments with the aim to analyse two more sub-characteristics of the quality of the model, namely the analysability and ease of learning, which are related, respectively, to the usability and maintainability.
- In the context of the family of experiments, it is planned to carry out a new design of the experiment so as to be able to confirm if the measures that were not validated in the first experiment could be useful when assessing the usability and the maintainability of the BPMs or whether, on the contrary, they are to be ruled out. In order to find this out, a new experiment will be conducted with students of the Master's degree in Software Technology in the University of Sannio (Benevento, Italy).
- Another part of what is planned is to develop the business process models within a company in the health sector, which would allow us to use experimental models of real cases.

APPENDIX A

Questionnaire of the group X, corresponding to the understandability tasks, Business process model 1 (Fig. 3).

Tasks to be carried out:

Write down the starting hour (indicating hh:mm:ss): ____________

1) Answer the following questions:

_____ 1. Can the *activity* **"To send payment voucher"** be performed if the option "Payment in cash" is followed in the node after the *activity* **"To charge amount"**?

_____ 2. The *Data object* **Payment Voucher** is an output of the *activity* **"To charge amount"**?

_____ 3. Is the *Start event* of the Applicant process a trigger of the *activity* **"To check documents"**?

_____ 4. When the *activity* **"To send payment voucher"** has been performed, has the *activity* **"To check Documents"** been already performed?

_____ 5. Is the *activity* **"Receive license to drive"** performed by the *entity* **Applicant** communicated to the **Traffic Office** *entity*?

_____ 6. Can the *entity* **Traffic Office** perform the *activity* **"To receive license to drive"**?

Write down the ending hour (indicating hh:mm:ss): ____________

2) According to your own criteria, how do you rate the Business Process Model's COMPLEXITY?

Very Simple ☐ **Rather Simple** ☐ **Normal** ☐ **Rather Complex** ☐ **Very Complex** ☐

Questionnaire of the group Y, corresponding to the modifiability tasks, Business process model 1 (Fig. 3).

Tasks to be performed:

Write down the starting hour (indicating hh:mm:ss): ______________

1) Carry out the necessary modifications to satisfy the following requirements:

1. It is desired to include the new *activity* **"To require license expire"** after the **"To make picture and get signs"**. This new activity receives as input the data *object* **"License expires".**
2. The data object **"License to drive"** must be recognized as output product of the *activity* **"To give license to drive".**
3. It is desired to include the new *entity* **"Treasury"** that receives from the *entity* **"Traffic Office"** information coming from the *activity* **"To send payment voucher"**.
4. It is desired to include an *intermediate event of time* to the *activity* **"To make picture and get signs"** indicating that this activity delays 15 minutes.
5. It is desired to include a new *activity* **"To pay amount"** after the *activity* **"To give documents".**

Write down the ending hour (indicating hh:mm:ss): ________________

2) According to your own criteria, how do you rate the Business Process Model's COMPLEXITY?

Very Simple ☐ **Rather Simple** ☐ **Normal** ☐ **Very Complex** ☐ **Rather Complex** ☐

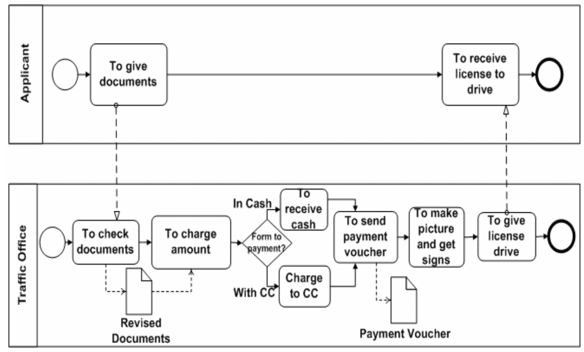

Fig. 3. Experimental Material: Business process model 1

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