

Knowledge Acquisition Model for the Clothing Industry in México

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Abstract: today the garment industry in México is vulnerable to complex problems. This type of industry is subject to influences which over time, modify the perceptions of those involved in the design process due to the fact that they face problems that have both objective and subjective characteristics. In this study we used interviews, direct observation methodology, and theoretical argumentation to obtain the experts' knowledge as they describe the problems that arise in the process of garment design for Mexican markets. The objective of this work is to generate a methodology so that the expert in this field will become highly specialized, resulting in heightened abilities and reinforcing them with the methodology of soft systems and the design management model. The results suggest that they are applicable to any area of design.

Keywords: system, knowledge, industry, systemic, systematic, knowledge representation, production rules, knowledge extraction techniques.

1 Introduction

The Clothing Industry in México has held a prominent role in society and in the economy due to its important contribution to the gross national product (GNP) and employment (Patlán, Delgado, Abdel, 2008). Nowadays the industry functions as a complex system, one problem generating another problem, and the influences to which they are exposed, modify their perception over time. Its complexity comprises the hard problems as well as the soft problems, among them are the following: poor integration of the productive processes in consumer goods with high value added tax; little capacity to adapt a process to manufacture similar products with style and quality; failure to develop from manufacturing assembly (maquila) of basic products to competitive products, resistance to change, low educational and cultural level of personnel, as well as failure to incorporate new technology into the process.

Trying to give and order to design of systems there are: 1) the hard systems or systematic systems and 2) the soft systems or systemic systems. Both approaches for solving problems in the real world (Check land and Scholes, 1994).

Herrscher (2008) defines *hard systems* and *soft systems* as:

The hard systems are those in which the problem is defined, the target is given, trying to achieve it in the most efficient manner possible. While soft systems are those in which the first problem is to define the problem, several actors have different objectives and social factors are complex and ambiguous.

With the later in mind, software engineering (systematic approach) has contributed to the operative function of the clothing industry system from information systems, design programs in 2D and 3D, CAD-CAM systems, and even specialized drawing, outline and pattern programs (Lectra Systems, Gerber Technology, Audaces, Optitex). However, from the knowledge engineering (systemic approach) there are no programs that contribute to its operation (Patlán, Delgado, Abdel, 2008).

Clothing industry experts are usually involved on site activities more often than with theoretical support. Information is structured in a cognitively complex form, making it difficult to understand, and constituting a bottleneck for the construction of knowledge *based system* (KBS). The acquisition of knowledge in an incomplete manner negatively influences the quality of KBS. Contrary, success in the acquisition of knowledge depends on the ability to conceptualize correctly the domain of the application thereby guaranteeing the quality of KBS. Taking this into consideration, the objective of the present work is to propose a methodology to extract knowledge from the dominion expert, in the search for, identification and description of complex problems and proposals for plans to optimize the design process of clothing in México, this through the utilization of interview techniques, on site observation, questionnaires and theoretical argumentation (Check land, 2006; Montaña, Moll, 2008).

The content of this project is organized as following: In *section two* the technique used for acquiring knowledge is described, as well as the general characteristics of the models used for research, definition and solving of complex problems (Soft Systems Methodology and the Design Management Model). *Section three* presents the construction of the EXITUS model and its function, and is described step by step. In *section four* the knowledge -based system (KBS) is described, and examples of the production rules used in the expert system (SBC-EXITUS), with the model previously developed. In *section five*, the model used to validate the system is described. Finally, the conclusions achieved are described in *Section six*.

2 Theory

The success or failure of KBS depends directly on the acquisition of knowledge (Méndez-Gurrola, 2007; 2012), to accomplish that, three large groups of techniques are used to extract that knowledge: manual, semiautomatic, and automatic. Within the group of manual techniques, interviews, protocol analysis, questionnaires, direct on site observation and the extraction of closed curves are emphasized. This technique is chosen for its ability to extract the particular type of knowledge being sought. The knowledge of the dominion expert in the design process in the clothing industry in México is based on processes and at the same time is episodic, meaning that part of the procedure is automated and each step of the process triggers the next. This knowledge is also based on experience which is of an autobiographical nature.

The interview technique is the most often used method since it allows acquiring different types of knowledge and at different levels in any field in the process of development of KBS (Alonso,

Guijardo, Lozano, Tomás yTaboada, 2004; Méndez-Gurrola, 2007; 2012). Depending on dates and content, interviews are classified as: initial, structured and unstructured.

The direct on site observation technique consists of observing the expert while he works on his daily tasks, in real life situations. There are no subjective interpretations in direct observation. This technique is more useful when the expert's activity is based on following a protocol or pre-formulated script and less useful when the expert's work is of a conceptual nature. (Alonso, Guijardo, Lozano, Tomás yTaboada, 2004; Pajares y Santos, 2006).

Questionnaires are a technique which consists of presenting a series of files with concrete questions to the expert which he must solve. This method allows the expert to consult books, magazines, etc. (Pajares, Santos, 2006; Palma Marin, 2008).

Since the domain expert lacks certain knowledge and abilities, necessary in the search for the definition and the solution of complex problems in the clothing industry in México, the missing information is obtained through the *soft system methodology (SSM)* and the *design management model(DMM)* (Check land, 2006;Patlán, Delgado, Abdel, 2008). The model was proposed by Check land (Check land, 2006), an adaptation of an Innovation Model (Montaña, Moll, 2008). It establishes a diagnostic of the design procedure and proposes improvements to optimize it and consequently the results obtained insure economic success. This method of investigation consists of a series of deep interviews with directives that intervene in the design process, analysis of secondary data (manuals, web page and technical reports) and non-intrusive observation. The design procedure model includes five activities: 1) corporate culture and design orientation, 2) concept generation, 3) design strategy, 4) resources and implementation, and 5) results, which are presented in Figure 1.

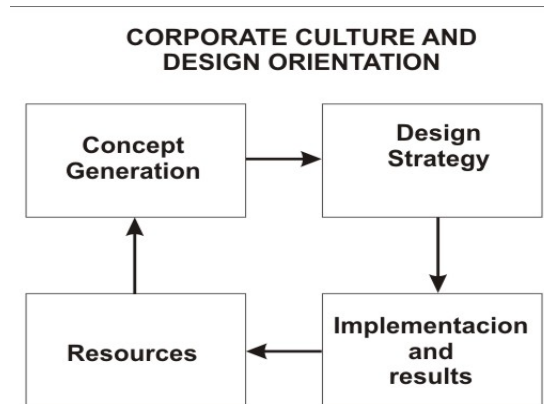


Figure 1. Design management model.

Soft System Methodology (SSM) is a systemic methodology that tackles soft problems and proposes changes to the system in order to improve its operation. It is a very useful way to approach complex social situations and to find answers to their corresponding problems. Check land developed this systematic model when he understood that it was not appropriate to investigate large, complex, and loosely structured organizational systems. He does not indicate solutions nor the criteria required to reach the optimal solution, rather he begins by investigating the facts of the problem situation until arriving at possible operational solutions for the system. This process is developed in seven stages which are divided into two activities: stages 1, 2, 5, 6 and 7 correspond

to *real life activities*; and stages 3 and 4 are activities of the *thinking of systems*, as is shown in Figure 2.

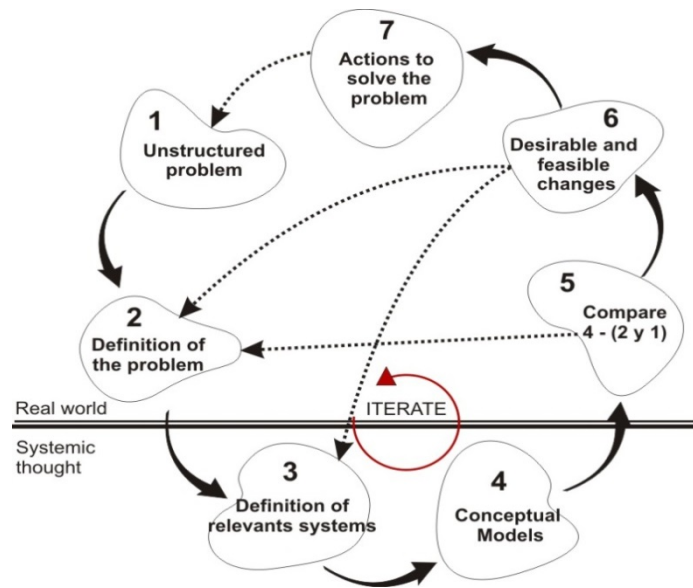


Figure. 2. Soft systems model

Advantages and disadvantages of these techniques are presented in Table 1.

Table 1. Advantages and disadvantages of techniques to obtain knowledge.

Technique	Advantages	Disadvantages
Interview	A great amount of knowledge is obtained.	Consumes large amounts of time, based on introspection.
Direct Observation	Non-introspective; information is obtained directly from the expert's work.	Consumes large amounts of time and its expensive.
Questionnaires	Inexpensive and not time consuming.	Introspective nature requires familiarity with the dominion in order to elaborate appropriate questions.
Theoretical arguments (SSM and DMM)	Based on success cases.	Must be familiar with the dominion.

3. Proposed Model

To gain knowledge the EXITUS Model (EM) is used. EXITUS arises from the fusion of SSM and DMM. Its objective is to seek, identify and describe complex problems that arise in the clothing design process as well as solution alternatives. It has seven principal stages: 1) unstructured problems, 2) problem definition, 3) root definition, 4) conceptual models, 5) comparison, (Check land, 2006; Patlán, Delgado, Abdel, 2008), 6) desirable and viable changes, and 7) actions to alleviate the problem. As shown on Figure 3.

EXITUS MODEL

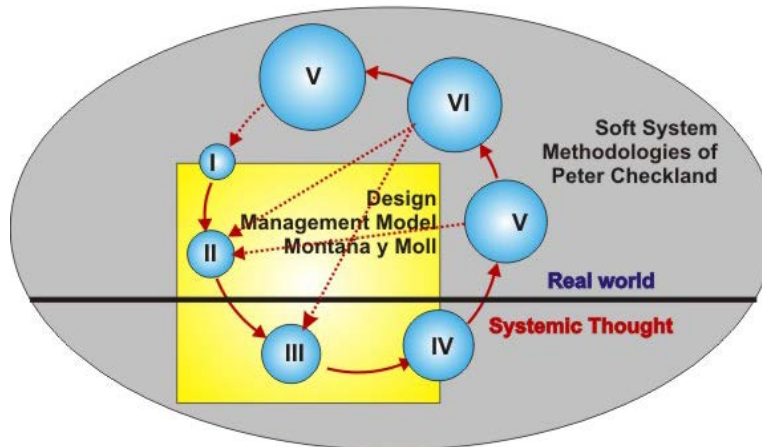


Figure 3.EXITUS Model

3.1. Stage I. Unstructured problem

The objective is to find the facts of the problem situation through interviews with people who have intervened in the design process, and nonintrusive observation in order to describe the problems origin without imposing structure on it. Two types of questionnaires are used: one with closed questions and the other with open-ended questions. The search is comprised of five aspects that together make up the analysis of the entire process (DMM):

- a) **Culture.** Verify the importance and value that the directors and the proprietors of the company give to design.
- b) **Concept generation.** How design intervenes in idea generation, in product concept definition, in the relationship of design with marketing, in opportunity exploitation, and in the relationship of the other departments with design, in making good use of in-house talent.
- c) **Design Strategy.** In synthesis, what is the role of design in company strategy, what is the development strategy for new products, what is brand strategy, how does design intervene in the different tools for brand creation, and how is the design process planned.
- d) **Resources.** Identify how internal and external teams are used, and what are the company needs for team development. Identify how internal and external design teams are used, what are the company needs for team development such as knowledge creation and designer training.
- e) **Implementation and results.** The execution of the design process: what degree of novelty and innovation is present in company design, how do different design processes relate with each other, how is design evaluated, and what is the final result for the company?

Given the example of the clothing manufacturer in Morelos state *company personnel do not utilize in their totality CAD systems in the design process, they prefer do to their work by hand, consequently they cannot meet deadlines for merchandise delivery.*

According to the EM, one seeks situations and facts that are involved in the problem. DMM diagnostic tools are used as shown in Table 2.

Table 2.Diagnostic tool

Fase	Questions
Culture	What role does design play in strategic planning? How is the design processed? How is the design communicated? Is risk managed? How is it managed?
Concept	What information and idea sources are used? Are product concepts defined? How is it done? What is the relationship between design and marketing? What relationship exists between design and other company functions?
Strategy	Is design a factor in company strategy? Is there a new product strategy? Is it defined? Is there an integrated design strategy? Is the design process planned?
Resources	Is there a design team? Is it internal or external? How does it work? Is there a person in charge of design? Is there a design budget? How is design knowledge created and transmitted? Is there a design team? Does it have a budget?
Results	What is the degree of novelty in design projects? Are design results consistent with other products and with company image? How could design be evaluated? What is the final result of new designs?

3.2 Stage II. Define the problem

Once the suspected problem has been identified and the facts ascertained of the problem situation, and solution has been suggested, the information is gathered, classified and revealed through a pictograph in which limits, structure, information flows, communication channels are illustrated. But mainly the human activity system is highlighted which is relevant in the solution of the problem, as shown in Figure 4.

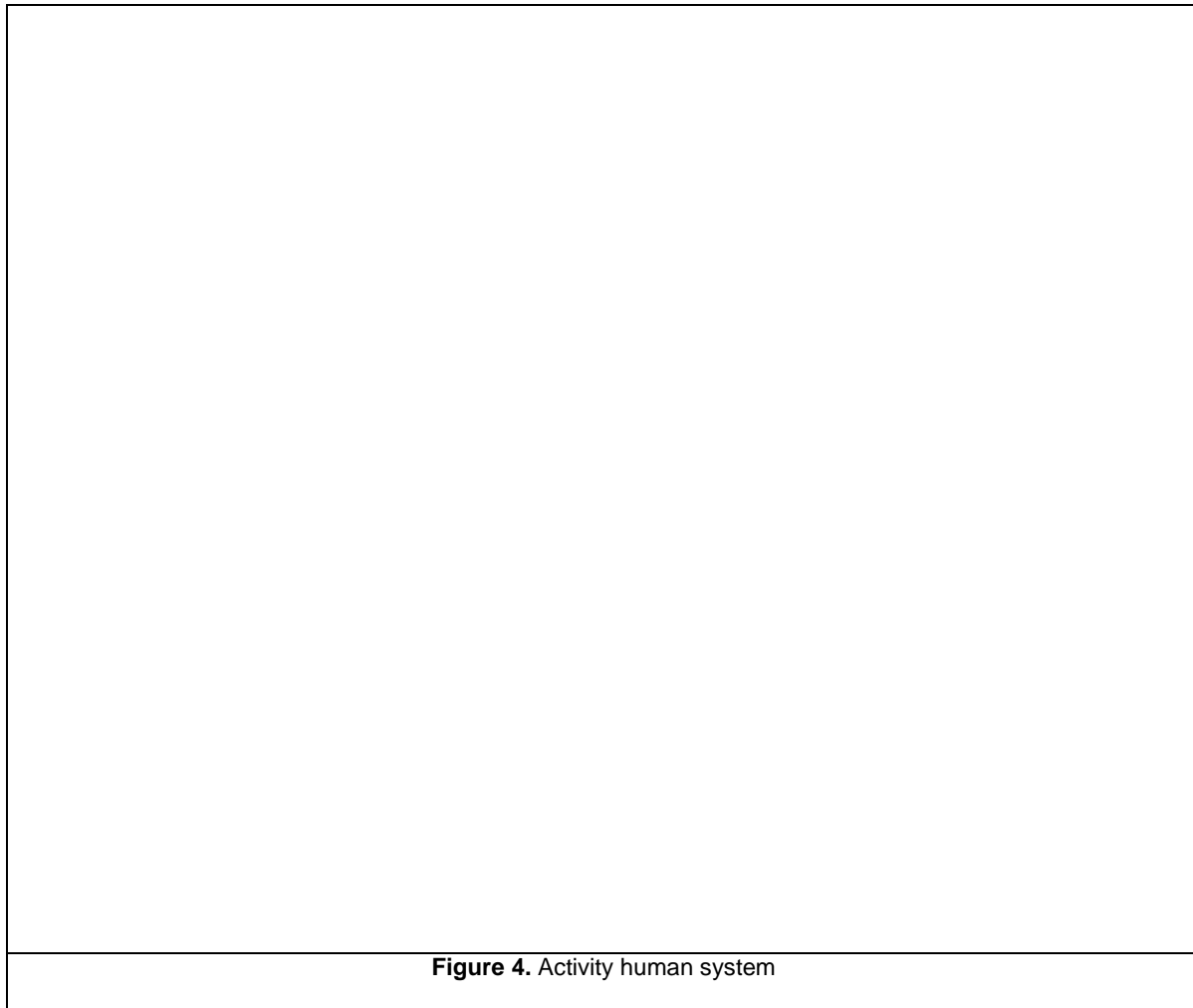


Figure 4. Activity human system

Based on the former, the problem is defined:

Computer assisted design (CAD) programs are not fully utilized because the design department is not considering a development program. Its function is based more on technological resources than on human resources, the personnel that operate the systems lack the skill and time to practice; knowledge is implicit in each employee but not documented. Design concept is poorly defined and limited to a single function; it is handled as if it were synonymous with fashion. Design is spoken about vision but not transmitted. Most people that intervene in the process consider design to be copying well-known brand clothing. Their designs and patterns are basic, and consequently they are not utilizing all of the functions that CAD technological system offers.

3.3 Stage III. Root definition

The purpose of root definition is to express the principal function of the activity system. The root is expressed as a transformation process that uses an entity as information input, and its transformation into a new one that result as an information output. The possible variables are identified in order to understand *how* the process could be transformed. This information is obtained through interviews and non-intrusive observation, as shown in Table 3.

Table 3.Central function of the activity by phase system

Phase	Root Definition
Culture	The company directors are involved in design management to produce innovative, quality products through design strategy, appropriate resource administration and an evaluation of the results plan.
Concept	Design, marketing and other departments generate ideas to define the products based on opportunity capture and internal capacity.
Strategy	Design contributes to company objectives based on new product development and brand strategies
Resources	Design manages the resources for designer development, knowledge creation and protection based on departmental needs.
Implementation	Directors evaluate the design to verify the degree of product innovation and the production process.

The root definition that corresponds to the question posed initially suggests that:

Marketing personnel, the fashion designer, the graphic designer and the company management technician should manage in its totality CAD systems in order to transform the greater part of the design process from hand drawn to computer-assisted design and management, in such a way that responses to commercial store demands are solicited.

3.4. Stage IV. Conceptual Models

Beginning with action verbs present in the root definitions, conceptual models are created, which represent ideally, activities which according with the root definition in question should be carried out in the system. The conceptual models represent *how* the transformational process is predicated on its basic definition. Conceptual models are extracted from the DMM based on facts and successful situations, of thirty-one Spanish companies of three different sectors: 1) furniture, 2) electronics, and 3) tourism endorsed by the *Spanish Federation of Design and Promotion Concerns* that stand out for the quality of their design. It is in this stage where the knowledge base can be enriched by more specific case studies in the clothing industry in México. Table 4 shows the conceptual models by phase.

Table 4.Conceptual model by phase

Phase	Conceptual model
Culture	Directors recognize the importance of design management as a competitive tool.
Concept	Design and marketing should understand their environment and work together.
Strategy	The entire design process is planned.
Resource	An individualized career development program is established for each one of the design team members that includes a training program and has an assigned budget.
Implementation	Design results are innovative, consistent with existing company products.

The conceptual model that corresponds to the question is: *Detailed planning in the design process considering departmental coordination and design leadership. Systematize the documentation gathered by knowledge of clothing pattern design and organize follow up meetings for projects in process with the object of transmitting such knowledge. Establish a training program for each of the design team members specifically with pattern technicians. Provide information systems that will facilitate the treatment and transmission of design knowledge accessible to all. Register all designs. Design objective should be true innovations that will contribute to differentiate the company.*

3.5 Stage V. Comparison of conceptual models with reality

Conceptual models are compared with (Stage IV) the current system situation. Once expressed (Stage II); the comparison intends to make existing differences emerging between that which is described in conceptual models and that which actually exists in the system. This exercise is useful to confirm and strengthen the knowledge obtained in Stages II, III, and IV. Table 5 shows this model comparison.

Tabla 5. Model Comparison

Model activity	Reality				
	Exists?	How?	Who?	Good/Bad	Alternatives
The objective of the design should be true innovations that contribute to company differentiation.	No.	Most people who intervene in the process consider design to be copying design from well-known labels. In this way their clothing and pattern design are basic.	Designes and pattern technicians.	Bad	Design original garments using CAD systems.

3.6 Stage VI. Design changes that are desirable, feasible and doable.

From the differences that emerged between the actual situation and conceptual models, changes are proposed to improve the process. Such changes should be evaluated and approved by the persons involved in the garment design process to guarantee that they are desirable, feasible and doable. In this way, knowledge is strengthened and enriched.

3.7 Stage VII. Actions to improve the situation of the problem

Finally this stage comprises the start-up of the changes designed in Stage VI, intended to solve the problem situation and its control. This stage is not the end of the methodology since its application is transformed in a continuous conceptualization cycle, as well as change implementation with a view to continued knowledge acquisition improvement.

4. Knowledge Base

4.1 Knowledge flow analysis

We later proceeded to define the knowledge base. To achieve this, a profound analysis of the process identifying the elements and their relationships was carried out in order to define the problem and propose solution alternatives.

Using EM, two sources of knowledge were found: one, the personnel who participated in the design process brought facts and situations while working; and in the validation of conceptual models and viable and doable changes. The other knowledge source is the DMM based on facts and companies that have been successful because of their designs, which could be further enriched with other success cases.

Three fundamental aspects in knowledge flow are observed: the search, identification and problem solution. The search for information is supported in Stage I and VII, the identification of the problem in Stages II and III and solution proposals in Stages V and VI, as shown on Figure 5.

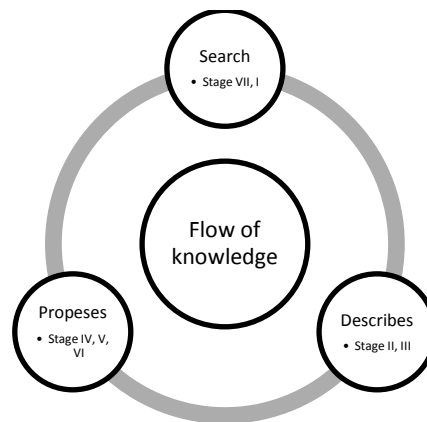


Figure 5.Knowledge flow

Search, Stage VII, I; Describes, Stage II, III; Proposes, Stage IV, V, VI; Flow of knowledge

One of the most critical areas of artificial intelligence is knowledge representation (Mora-Torres, 2007; 2011; Mora-Torres, Laureano-Cruces, Ramírez-Rodríguez, Espinoza-Paredes, 2009); due to the variety of ways that knowledge takes. The problems involved in the development of a knowledge representation are complex, interrelated and dependent on the target. This representation depends on the environment that is being modeled (Méndez-Gurrola, Laureano-Cruces, Ramírez-Rodríguez, 2007).

The cognitive engineering has adapted various systems of knowledge representation, implemented in a computer are very close to the models developed by cognitive psychology to emulate human cognition. There are several techniques for knowledge representation, among them: production rules; frames and scripts; propositional logic; predicate logic; fuzzy logic; associative networks; Bayesian networks; conceptual graphs and fuzzy cognitive maps, among others (Laureano-Cruces, Ramírez-Rodríguez, Mora-Torres, de Arriaga-Gómez, Escarela-Pérez, 2010; Laureano-Cruces, Rodríguez-García, 2012; Laureano-Cruces, Mora-Torres, Ramírez-Rodríguez, de Arriaga-Gómez, 2011; Laureano-Cruces, Guadarrama-Ponce, Mora-Torres, Ramírez-Rodríguez, 2011).

4.2 Production rules

This section describes the implementation of production rules as they are implemented under the VisiRule (<http://www.lpa.co.uk/ftp/visirule.ppt>) software which allows us to have a graphical view of the rules (Méndez-Gurrola, Laureano-Cruces, Ramírez-Rodríguez, 2008). The rules are the most common form of representing knowledge due to its simplicity, and become the immediate formulation of the principle of causality.

VisiRule is a tool for creating decision support software by drawing charts, and is a graphical tool which lets you draw questions and expressions which are mapped into rules (Shalfield, 2008). This generates source code which can be compiled and executed in-situ or exported and used in a separate program. VisiRule combines elements of rule-based processing, knowledge-based processes, knowledge management, decision support tools and artificial intelligence to produce a practical and flexible modeling and problem solving tool. Figure 6 shows the VisiRule architecture.

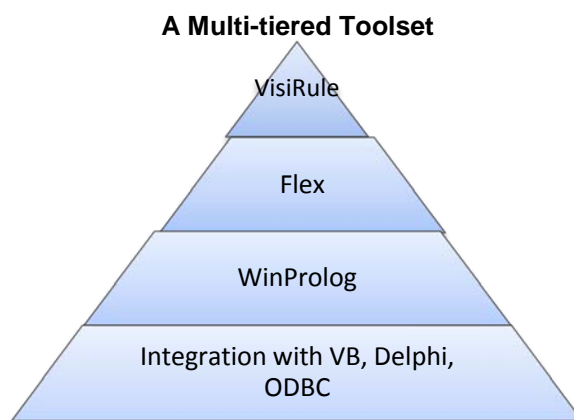


Figure 6. VisiRule architecture

Key features of VisiRule include: intelligent drawing and design tool, automatic layout support, configurable viewing options, shareable Charts, in-situ execution and code generation, rich set of question types, powerful expression handling logic, code boxes, statement boxes, 64-bit Arithmetic, multiple document Interface, dynamic link libraries, direct Windows API interface, automatic configuration, language interfaces, true 32-bit implementation and small memory requirements (http://www.lpa.co.uk/vsr_det.htm).

VisiRule provides the automatic construction of menu dialogues from questions. These are populated by items inferred from expression boxes throughout the flowchart tree which have a path to the question. The provision of statement boxes and code boxes, plus the ability to link unconventional *WIN-PROLOG* and/or *Flex* program files, makes *VisiRule* a very powerful charting system which can do the simple things well and the more complex things. *Flex* is an expressive and powerful expert system toolkit which supports frame-based reasoning with inheritance, rule-based programming and data driven procedures fully integrated within a logic programming environment, and contains its own English-like Knowledge Specification Language (KSL) (Westwood, 2007). *WIN-PROLOG* is the leading Prolog compiler system for Windows-based PCs. Prolog is an established and powerful AI language which provides a high-level and productive environment based on logical inference (Steel, 2010). *WIN-PROLOG* 4.9 is the latest version of LPA's true 32-bit Prolog compiler, and is available for all versions of Microsoft Windows, from Windows 98SE right up to the Windows 7. Key features of *WIN-PROLOG* include: XML, JSON, Windows 7, Windows Sockets (WinSock) support, soft meta-predicate definitions, extended HTML help, word wrap option, Musical Instrument Digital Interface (MIDI), dynamic memory reallocation, automatic configuration, multiple document interface, common dialog boxes, source level and box model

debuggers, rich graphics facilities, efficient runtime system, dynamic link libraries, dynamic data exchange, language interfaces, small memory requirements, 64-bit arithmetic, operating system control, user-definable system hooks, special data types, sophisticated data compression, powerful data encryption, secure hashing and message digests, full range of options (http://www.lpa.co.uk/win_det.htm).

By combining Flex and Prolog a hybrid expert system with a powerful package of artificial intelligence tools was created, generating a pleasant work environment for expert-system or knowledge-based system developers.

Fundamentally, a rule consists of two parts:

1. **Background:** also called the left, because the rules can be written as $a \rightarrow C$. Contains clauses that must be met before the rule is evaluated or executed.
2. **Consistent:** also called right, indicates the conclusions that follow from the premises (declarative interpretation) or the actions that the system must perform when you run the rule (mandatory performance).

The rule-based systems represent knowledge in terms of, if-then rules, facts and an interpreter that controls the application of rules, generating events.

The power of a rule is based on the logic that supports the expressions of the conditions and conclusions. The rules represent the knowledge used in the form IF - THEN, you may be used to express a wide range of associations. Example of simple rules to be implemented (Méndez-Gurrola, 2007; 2012):

1. If a supernova occurs, then causes a supernova remnant.
2. If a supernova occurs, then it can cause a pulsar.

To carry out the implementation of the rules it was used VisiRule (Spenser, 2007), the decision diagram is represented in Figure 7.

VisiRule is a graphical tool developed by Logic Programming Associates, LTD (LPA) that lets you draw and execute decision trees (Méndez-Gurrola, Laureano-Cruces, Ramírez-Rodríguez, 2007). The main buildings are VisiRule nodes representing questions and / or computable functions and expressions that keep the different routes through the network. VisiRule generates code in the form of rules in Flex (LPA expert system) that could be implemented, inspected and exported for inclusion in external applications (Konar, Jain, 2005). In Table 6, modules and sub modules with their respective problems and solutions can be seen.

Table 6. Modules, problems and solutions

Module	Name	Sub modules	Problems	Solutions
A	Corporate culture and design orientation	role, management, communication, risk	P1,...,P16 P17,..., P32	S1,..., S16 S17,..., S32
B	Concept generation	source, product, market, function	P33,..., P48	S33,..., S48
C	Design strategy	design, novelty, integrated, process equipment, person responsible,	P49,..., P64	S49,..., S64
D	Resources	knowledge, budget		
E	Implementation and results	novelty, image, evaluation, result	P65,..., P80	S65,..., S80

As future work the knowledge base will be expanded to include additional aspects that will contribute to the search for complex problems. The function of the third block is to describe the problem as it was diagnosed, and the fourth block consists of proposing alternative solutions or action plans. As an example, Table 7 demonstrates the Resource Phase class and its attributes to develop rules.

Table 7. Classes and attributes in rule development

Class: Resource Phase	
Attribute	Attribute Value
Aspect	Work, budget, knowledge, team
Team work	1,2,3,4
Person responsible	1,2,3,4
Knowledge	1,2,3,4
Configuration	1,2,3,4
Diagnostic	Never, occasionally, often, always
Solution proposals	Encourage, communication, create internal design team, communication exists between internal and external design teams. Designate a leader, formalize a design department, and fix a budget. Document and systematize knowledge, register designs. Support development activities, fix a development budget establish a career program.

Taking into account the former, next section shows some system rules:

Rule 1

If development is 2, then design team formation has been considered occasionally.

Rule 2

If knowledge is never, then documenting knowledge is required.

Rule 3

If Person responsible is 2, then occasionally there has been a design budget and a design leader.

Rule 4

If knowledge is 3, then often knowledge has been documented and is available in the company.

Rule 5

If resources are often, then development activities require strengthening, follow-up on career programs and increase development budget.

On the other hand, Figure 7 presents a fragment of the tree depicting the search and description of the problem (P1, P2,... P16), as well as the solution proposals (S1, S2,... S16).

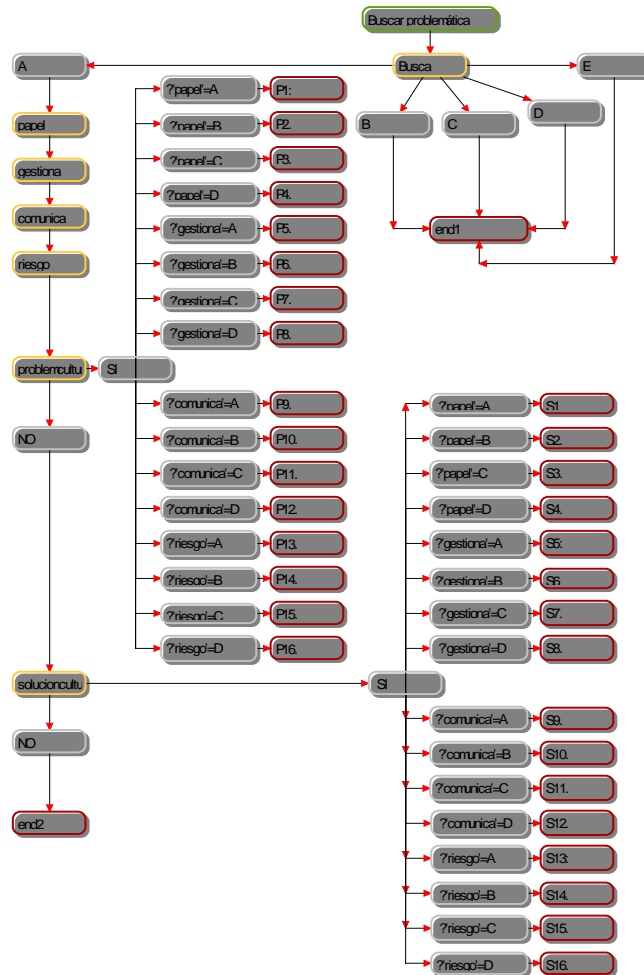


Figure 7. Drawing chart the resources module

4.3. Implementation of SBC-EXITUS

By means of LPA WIN-PROLOG VisiRule, graphic drawings representing production rules are made: GREEN boxes indicate the PRINCIPLE, YELLOW boxes indicate QUESTIONS. The WHITE boxes indicate OPTIONS that must be selected according to the question. The RED box indicates the CONCLUSION reached after the analysis of rules; that is, the logical conclusion according to the series of proposed questions. In other words, it defines the complex problem. Each module identifies sixteen problems and sixteen solutions. The conjunction of modules generates one hundred and sixty precepts. Figure 8 shows the drawing chart of SBC-EXITUS.

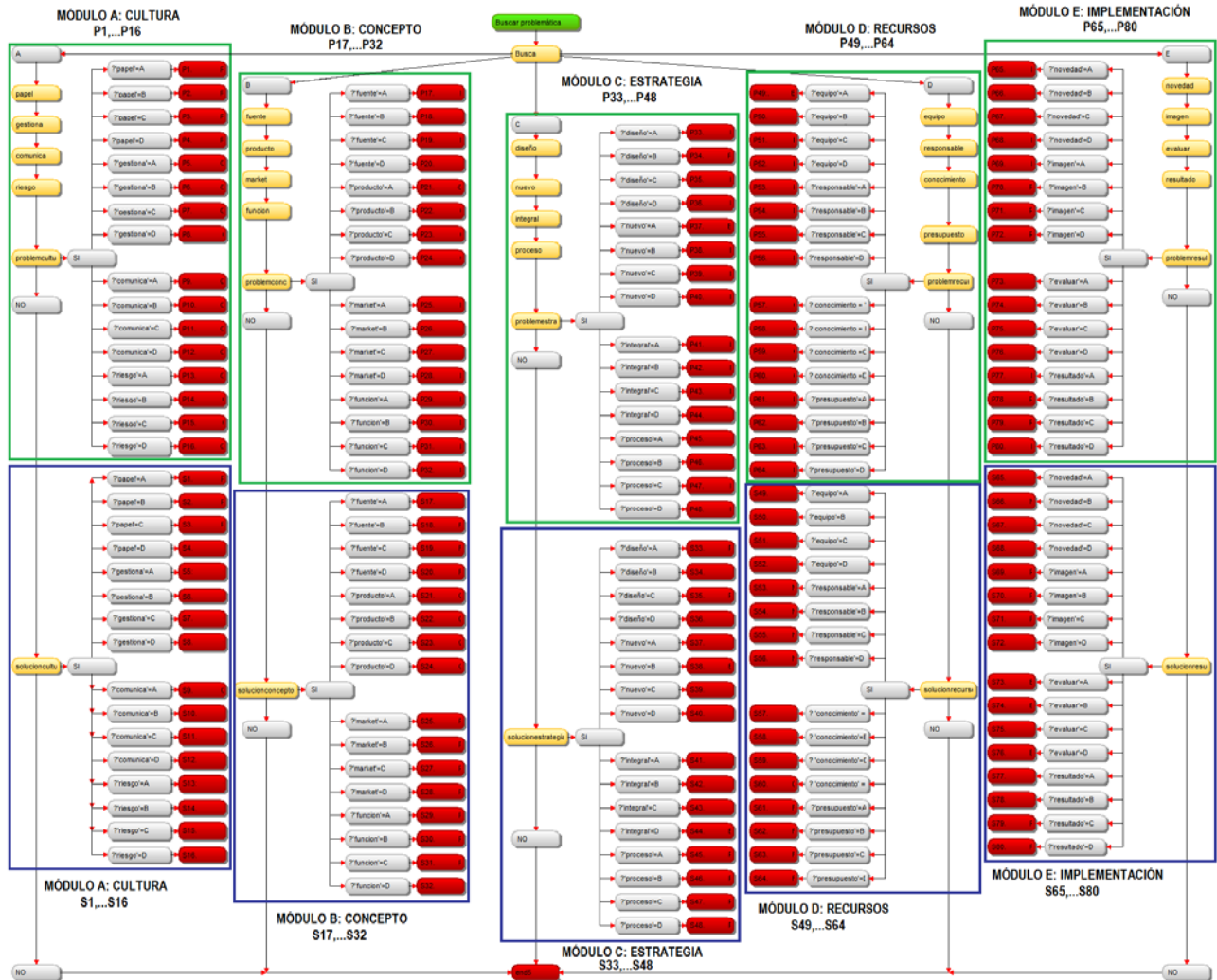


Figure 8. Drawing chart SBC-EXITUS

The green text boxes, frame the modules that describe the problems. In the YELLOW boxes, starting from the top and going down, the sub modules are shown; and in the red boxes, the problems. The blue text boxes frame the modules that describe the solutions, and the solutions are shown in Red boxes running from the top down.

Once the graphic representation of the rules of each of the modules is done in the boxes: green, yellow, white and red; a FLEX code is generated. This code creates a graphic representation of the result in windows. In Figure 9 the windows generated by FLEX are shown.

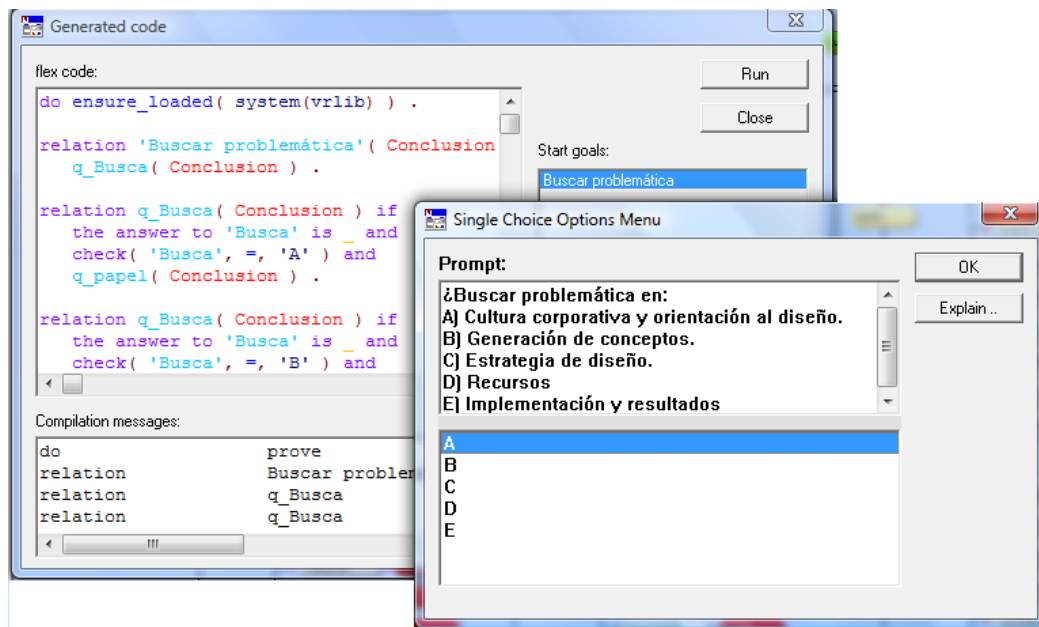


Figure 9. SBC-EXITUS searches for complex problem facts and situations in modules A, B, C, and D.

Based on point 3.1. Stage I. Unstructured problem: *company personnel does not utilize in their totality CAD systems in the design process, they prefer do to their work by hand, consequently they cannot meet deadlines for merchandise delivery.*

SBC-EXITUS looks for facts or situations that are involved in the problem. In each one of the modules A, B, C, D and E that refer to *Culture, Concepts, Strategies, Resources and Implementation* respectively, as described in point 3.1 Stage I. Unstructured problem. Each module represents a segment in the management of the design process and it is where the complex problem is located. Figure 9 illustrates how SBC-EXITUS searches for the problem.

Given the characteristics of the complex problem in the example above, we observe that the aspect that needs evaluating is the Resource module, since it is responsible for: a) identifying how internal and external design teams are used, b) what the company needs are for further development of human resources, c) how are the creation of knowledge, and the forming of designers are done, and d) how is this knowledge protected. Nevertheless, it should not be implied that other stages are isolated, because it is important to contextualize each one of them. Figure 10 shows how SBC-EXITUS looks for facts and situations in the sub modules.

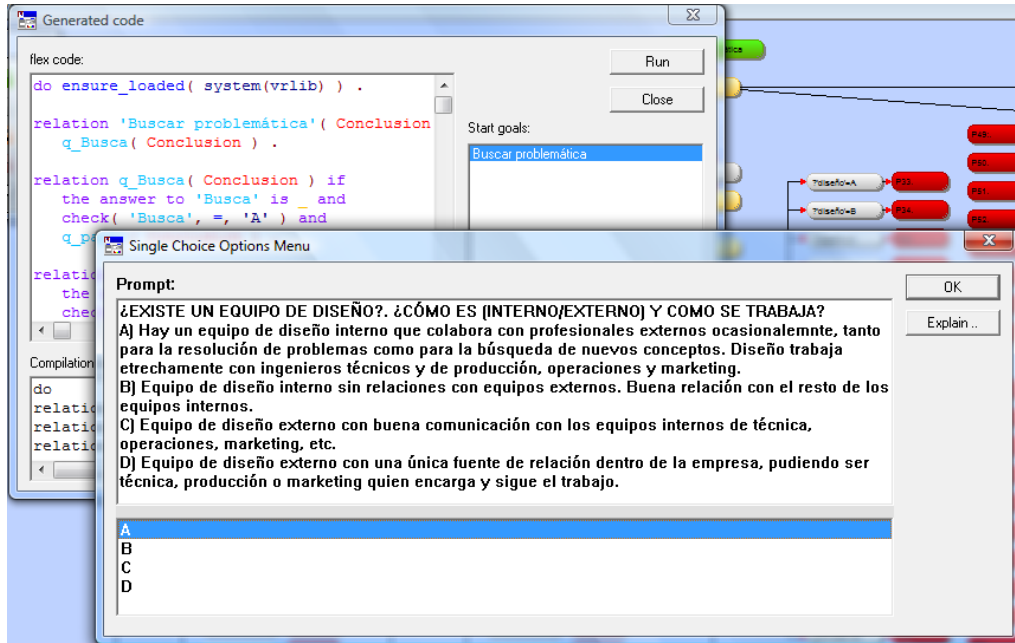


Figure 10. **SBC-EXITUS** looking for facts and situations of the complex problem, in the resource module, team sub module.

Once the facts and situations based on the questions asked in Table 2 are identified, the system describes the problems in a series of sub modules that are shown in Figure 11, where reference is made to the problems of the *Resource module* through windows. In this case, the sub modules are: team, person responsible, knowledge and budget. In Figure 12 the respective solutions are shown.

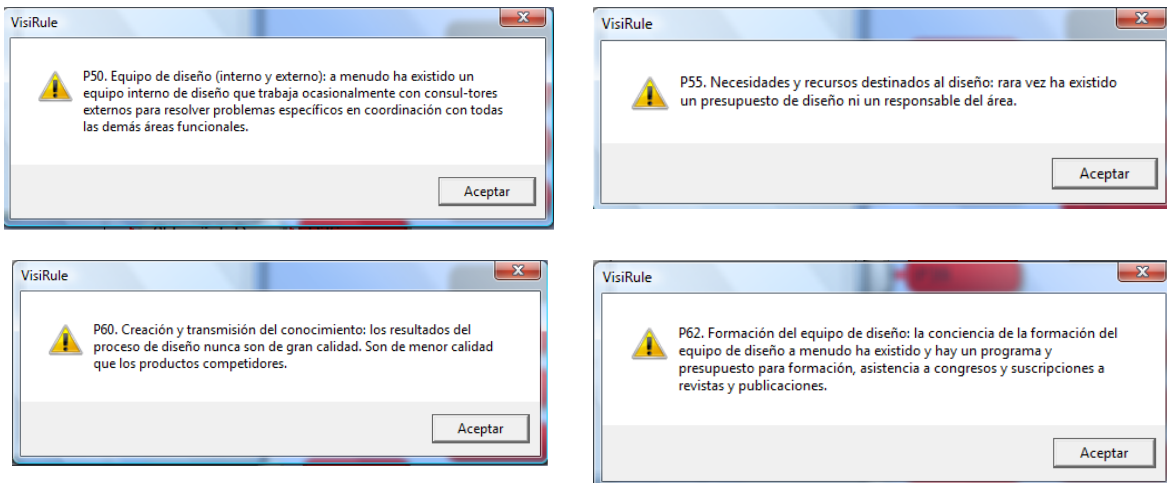


Figure 11. Problems: 50, 55, 60 and 62 identified by **SBC-EXITUS** of resource module, sub modules: team, person responsible, knowledge and budget.

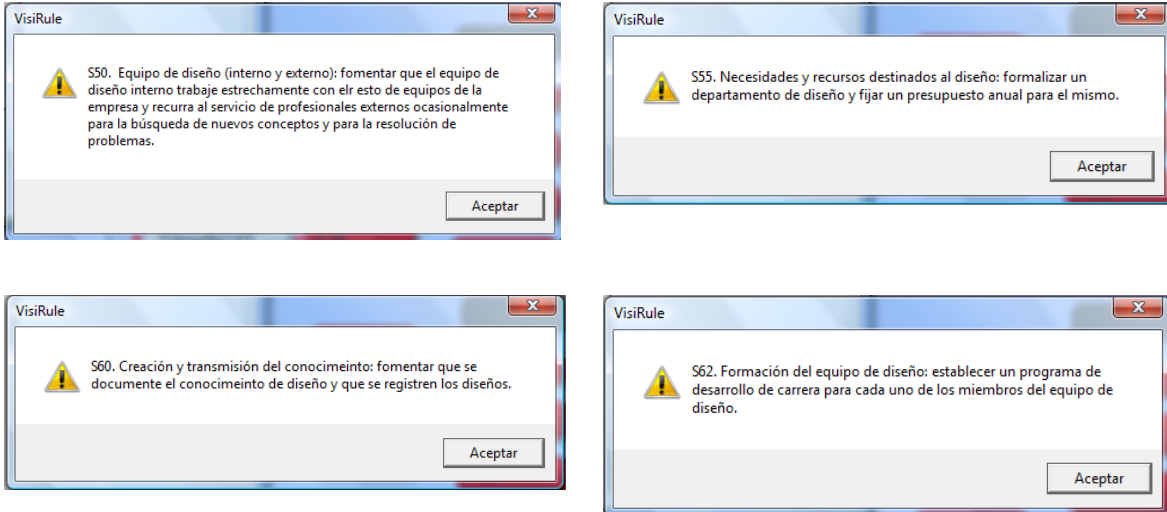


Figure 12. : Solutions: 50, 55, 60 and 62 identified by SBC-EXITUS of resource module, sub modules: team, person responsible, knowledge and budget.

Based on the conclusions determined by *SBC-EXITUS*, the designer will be able to identify the complex problem in a faster, easier and less costly manner. Which will enable the designer to enrich Phase I, II, III and IV, and to advance from Phase I to Phase V, of the EXITUS model as described on point 3 *Proposed Model*.

5 Model validations

Stages V and VI of the EM facilitate knowledge validation through those involved in the process, including personnel with empirical knowledge, as well as theoretic knowledge. This validation takes place with the entire team where all express their opinion, contribute information and validate facts and information. Since these are the same people who carry out the process, they not only generate knowledge, but also validate it. This knowledge is valid by two filters: Stage V and Stage VI of the MS.

The objective of *SBC-EXITUS* validation consists in comparing actual system performance to its expected performance, and to generate proof that the system reaches a level considered acceptable, that is what we call *validation of the system vs. experts*. To this effect, stages V and VI of the SSM (Figure 2) are used. Stage V compares *conceptual models* with *reality* and stage VI designs desirable, viable, and feasible changes.

In system validation, the conceptual model represents the knowledge model (searching for problems and solutions), reality represents the way in which the dominion expert solves the problem. We intend to find differences when comparing the knowledge model and expert knowledge. From these differences changes are proposed to improve SBC-EXITUS. Dominion experts should evaluate and approve the changes in order to guarantee that they are desirable, viable and feasible. Figure 13 shows the validation model.

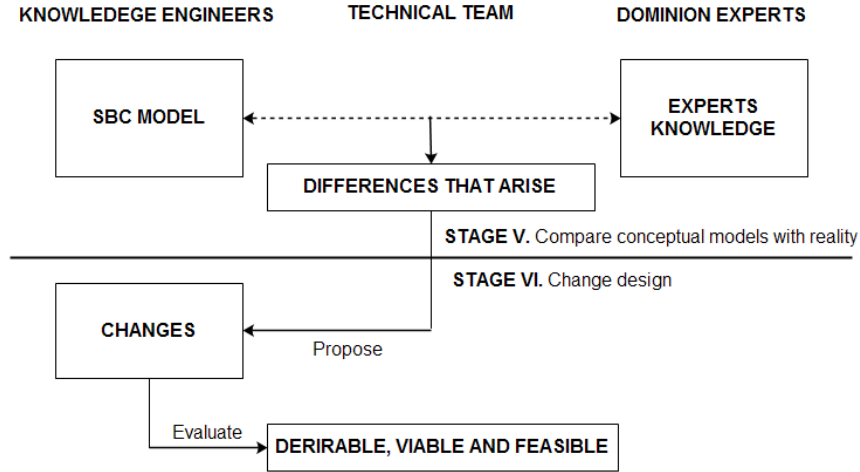


Figure 13. Validation Model

5.1 Comparing SBC model to reality

The process consists of a recurring process of questions-answers-questions and uses a group of experts and a moderator in charge of compiling the information and filling out forms: Table 7 and Table 8. The moderator exhibits the SBC model and each expert emits his criteria. Recurrence is obtained by presenting many times the same questions. Afterwards group answers are emitted, taking into account the most viable one, that is, the most promising. A model of comparison is generated to validate the activity of the model by verifying: a) does it exist? b) how is it accomplished? c) who carries it out? d) is the activity correct or incorrect? This can be seen in Table 7.

Table 8. Comparative model

Models Activity	Does it exist?	How?	Who?	Good/Bad
Investigate the problem	YES	A diagnostic tool is used to investigate problem facts and situations in five areas: corporate culture, concept generation, design strategy, resources and implementation.	Expert	Good

5.2 Desirable, viable and feasible changes

From the differences that emerge in the comparison model, changes are proposed and later evaluated following the same recurrence method used in the prior step, as illustrated in Table 9.

Table 9. Desirability and viability of SBC models

Model's activity	Differences	Desirable?	Viable?	Feasible?
Investigate the	Consider other specific	YES, provides most	YES	YES

6 Conclusions

When one simulates human behavior, the hardest thing is to choose a knowledge representation that conforms as closely as possible to its emulation. According to Konar (2000), choosing a given type of knowledge representation is an art that is discovered little by little. And this is true as one designs and assembles a representation, when one realizes how far we are from imitating the design of the human brain processes, and discovers or invents methodologies to achieve it, combining the results of investigations into knowledge representation, cognitive psychology and cognitive engineering (Méndez-Gurrola, Laureano-Cruces, Santillán-González, Ramírez-Rodríguez, 2008; Mora-Torres, et al. 2009).

Solving any complex situation in the design process function of the clothing industry is no easy task. It requires plenty of experience in the manufacturing process. One needs the ability to identify the signals emitted by complex situations, and being able to stop them in time before they create irreversible damage. By merging the SSM and DMM with the experts' abilities and knowledge (the result being the EXITUS model), makes knowledge modeling possible. A problem cannot be solved if it is unknown, if the problem persists and grows it becomes more complex. By describing a problem, based on: its origin, its relationship and its effects, it also confers the ability to solve it. Thereby, an SBC with the characteristics presented in this paper, not only improves the design process function as a whole, it also contributes to achieving corporate success. Finally, it influences directly on: 1) a quality product, 2) market positioning, and 3) good economic results.

The SBC-EXITUS was tested and endorsed by expert management designers. When a designer identifies a complex problem using the SBC-EXITUS system, he is capable of verifying its existence with facts and real life situations. This enables quicker decision making decisions, which: 1) saves time, and 2) money, due to the fact that a non-desirable state of affairs may be contemplated in advance.

In this project an SBC named SBC-Exitus has been implemented using the soft system methodology (SSM) and the design management model (DMM), with the purpose of detecting possible problems in the design process of the clothing industry. Its implementation is developed by the use of production rules.

Utilizing the methodology and the production rules like knowledge representation technique, make possible to acquire dominion knowledge in complex problems as in the study case clothing industry in México. This approach is also applicable to other areas of design.

Acknowledgements: This work is part of the research project undertaken by Karina Santiago-Santiago, to obtain the PhD degree in Diseño: Nuevas Tecnologías at Universidad Autónoma Metropolitana-Azcapotzalco. It is also part of the project Computación Suave y Aplicaciones (Soft Computing and Applications) in the line applications of engineering design, at Universidad Autónoma Metropolitana-Azcapotzalco, funded by the same University. It is also part of project Líneas Innovadoras de Investigación Aplicada y Desarrollo Tecnológico (LIADT) of the Programa de Mejoramiento del Profesorado (PROMEP) and of the División Académica de Mecánica Industrial (DAMI) of the Universidad Tecnológica Emiliano Zapata del Estado de Morelos (UTEZ).

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