Didactic Networks and exemplification

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Abstract. After a general overview in a previous paper [10], in which we proposed Didactic Networks (DN) as a new way for developing and exploiting web-learning content, we offer here a deeper study showing how to use them for web-learning design and content generation based on Instructional Theory with the coherence guaranty of the RST [3].

By using a set of expressivity patterns, it is possible to obtain different final "products" from the DNs such as different level or different aspect web-learning lessons, depending on the target, documents or evaluation tests.

In parallel we are defining the Fundamental Cognitive Networks (FCN), in which we deal with the most common patterns human being uses to think and communicate ideas. This FCN set reuses the representation of Concepts, Procedures and Principles defined here, and it is the main topic of a paper we are working on for the very near future.

1 Introduction

The RSR (Rhetorical Semantic Relations) we have proposed in a previous paper [8], have been defined as a set of relations valid for representing any kind of knowledge. By combining this set of relations with knowledge nodes, we are able to represent knowledge by means of a certain kind of concept map [5], with a set of topological and semantic constraints [7] that we call "knowledge network" (KN).

The KNs can be the origin of web pages and web site content, by applying some visual transformations such as what we are explaining here. Each of the knowledge nodes in any KN includes a set of attributes. For the present paper, the most important to take in account are a Title, a textual description, a set of graphics, a set of audiovisual sequences, a set of equations and, finally, a set of Synchronization parameters. Providing the adequate information for each one of the nodes in a KN, these visual transformations automatically produce web pages and web sites.

Once we have defined the "Didactic Networks" (DNs) for representing didactic methodology for applications in web-learning [10], we are ready to provide a complete description of how DNs support each of the steps of the methodology.
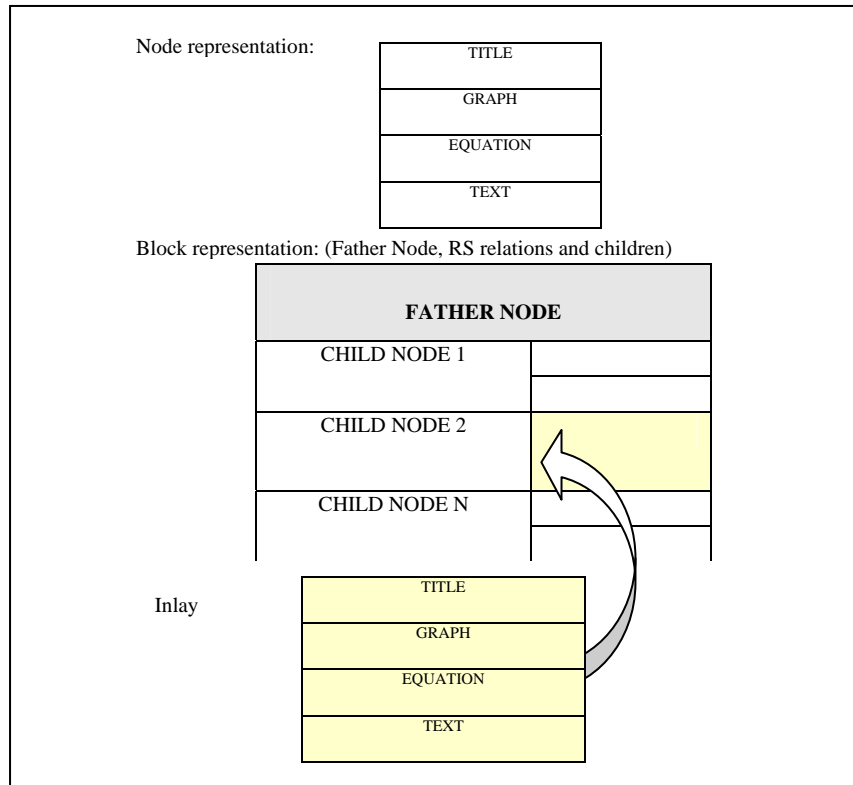
Fig. 1. Visual Pattern

2 Didactic Networks for memorization and examples

Reigeluth treats memorization as an invariant task, because we can see concepts, procedures and principles as a list of items (facts, steps and events, respectively), making a distinction between ordered and non-ordered lists.

The three major tactics to facilitate memorizing are Chunking, Repetition and Mnemonics. The method consists of the following steps as well as some motivational tactics depending on the student's needs, not considered in the general case [6]. (The convention for RSR representation in DNs is by means of an arrow, labeled by means of an ellipse including action name and a content type specification.

2.1 Presentation of the object to memorize

The methodology simply requires a list of elements. We define three different DNs that will be generalized to be also a FCN: Parts Network, Principle Network and Procedure Network.
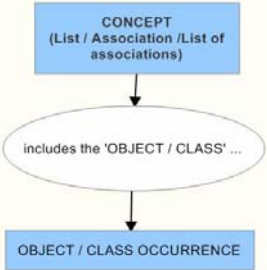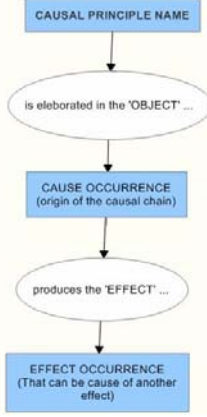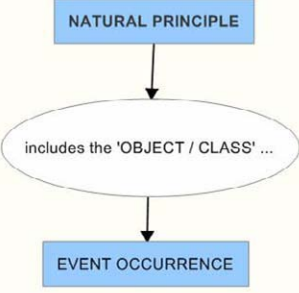
a. Concept	b. Causal principle	c. Natural principle
This semantic network shows a concept as a set of elements (list or group of particulars).	We have included additional information regarding causal RSR, not required by BMI. [8]	In a natural principle presentation, it is important to show the sequence of events, and no other relation

Fig. 2. Presentation of Concepts and Principles.

Some examples, corresponding to the basic concepts in the eigenvalues problem [4]:
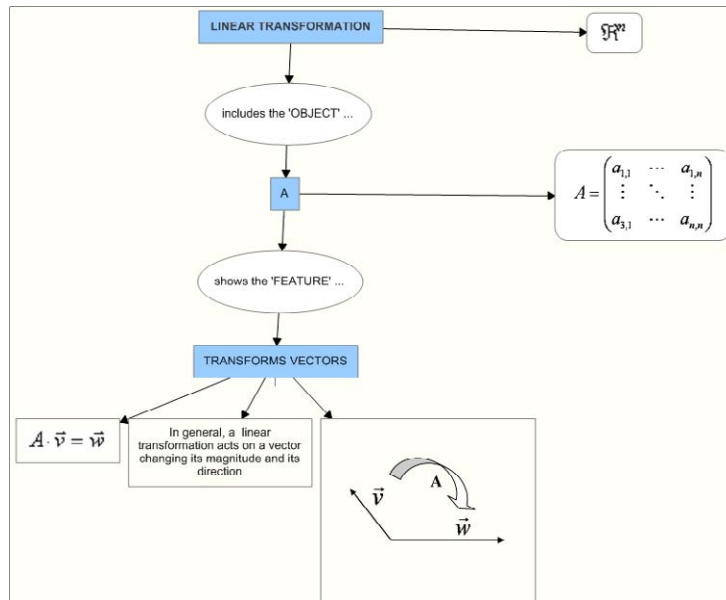

Fig. 3. Didactic Network for the Concept of Linear Transformation

By applying the visual pattern defined in Fig 1 we will automatically obtain the next appearance for the web page:
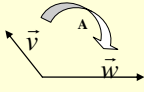

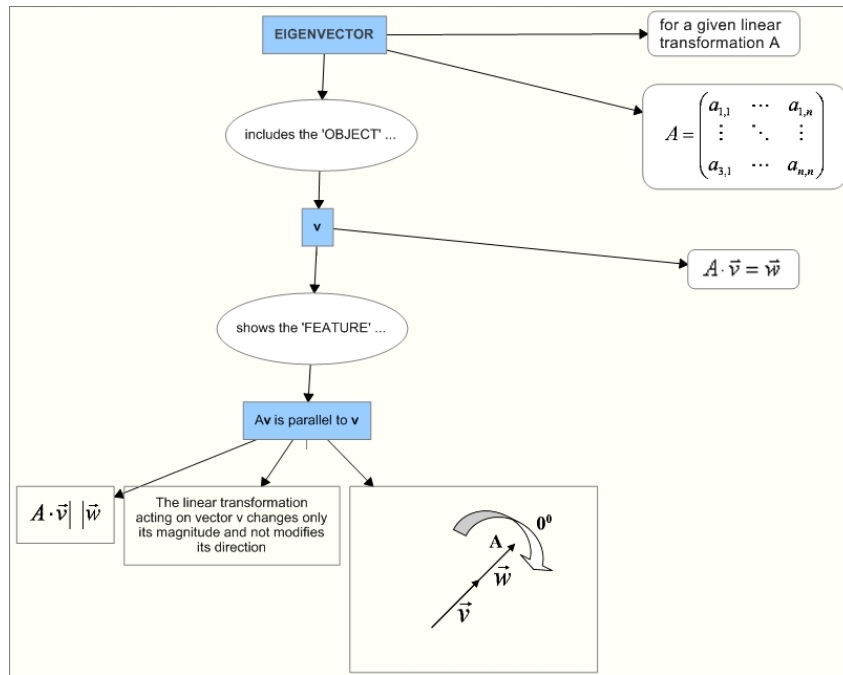**Fig. 4.** Application of a Visual Pattern to the Didactic Network

Fig. 5. Didactic Network for the presentation of the Concept of eigenvalue

d. Procedures

For a procedure presentation, the first step is the Objective declaration followed (optionally) by the description of the sequence of steps required to achieve it. If necessary, it is possible to specify the condition and action corresponding to each step.
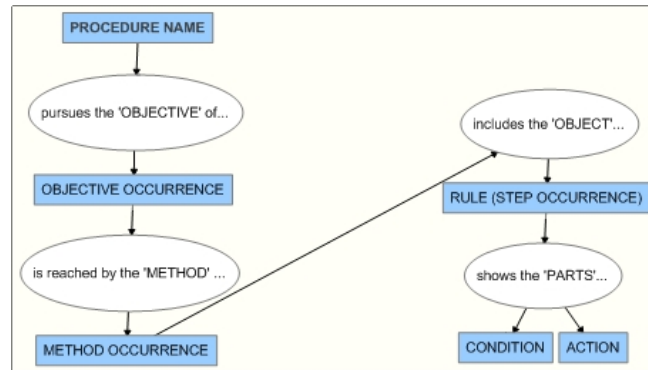
4

Fig. 6. Procedure presentation

Enrichment Tactics for difficult content

In the case of long lists to memorize for concepts, procedures or principles, the use of power tactics, such as Chunking, Repetition and Mnemonics is recommended, by using the didactic network provided in the present section.
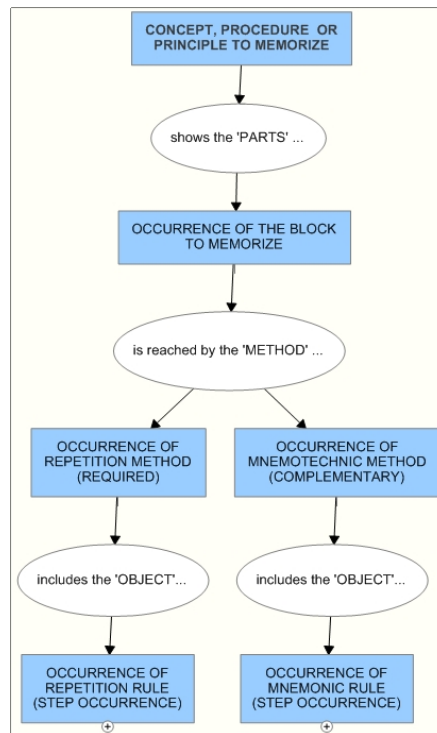

Fig. 7. Enrichment Tactics for difficult content

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2 Prompting and Practice.

In the last step, the methodology suggests requesting the learner for feedback about the knowledge transference. A software module will be responsible for an automatic test generation. Taking into account that all the information is ultimately a list which is independent of the knowledge nature, suitable questions include the following:
- For a given element in a list, determine the next element
- For a given element in a list, determine the previous element
- If a list of associations, for a given element, determine its associated one

3. Didactic networks for concept application (classification)
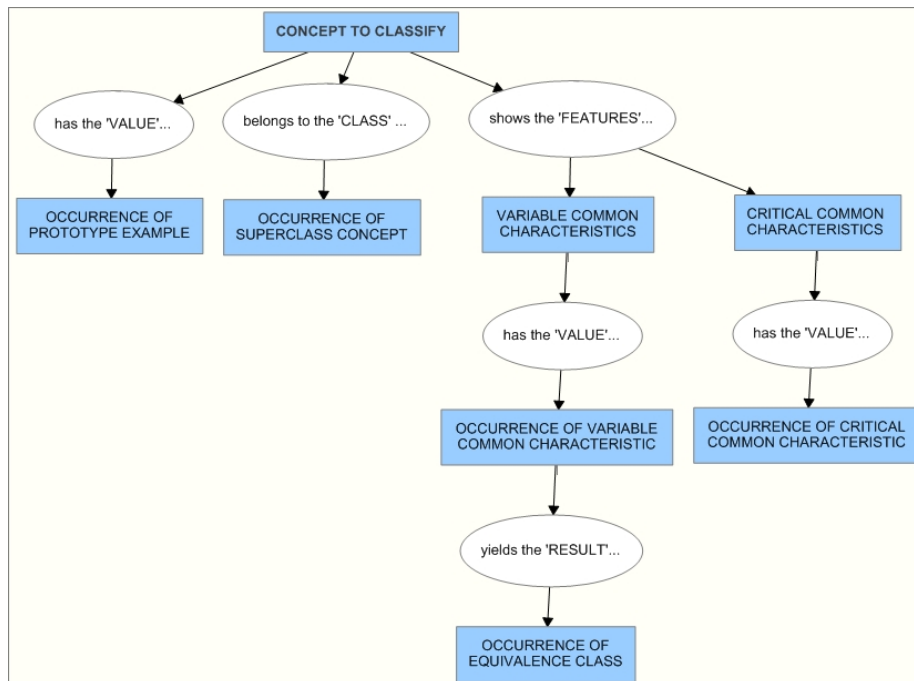
3.1 Presentation

Fig. 9. Concept classification

The proposed network includes all sections required by BMI: The Prototype formation (common characteristics), Generalization (variable characteristics) and Discrimination (critical characteristics).

3.2. Exemplification

The objective is to provide a useful guide for a suitable exemplification. We should create examples that are as divergent as possible, by specifying common variable features (dimension of divergence). The contrast with a non-example showing a non-fulfillment of critical characteristics is a useful resource to complete the concept transmission. The didactic network supporting this phase is based on the concept classification:
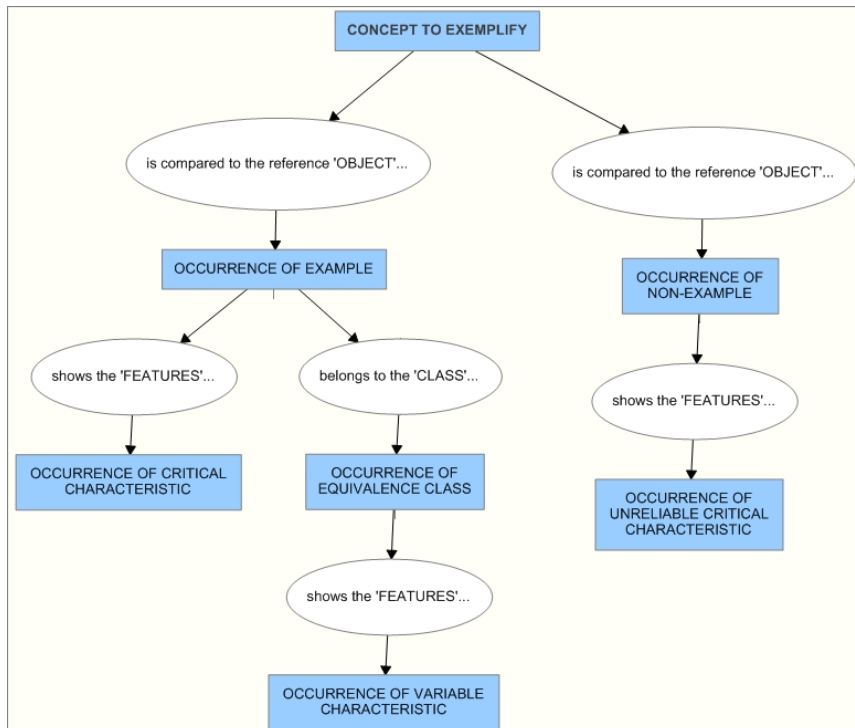

Fig. 10. Exemplification of concept application

3.3. Presentation of the process of Concept classification (application).

In most cases, the classification procedure is very simple: however there are situations in which it is not so easy, and it is necessary to carry out a strategy to do that. For both situations, the didactic network supporting this phase is related to the two alternatives: looking for unreliable critical features for the candidate exclusion and looking for matching for the candidate acceptance. (Fig 10)

3.4. Practice, Classification Test and Feedback

Based on the same Fig.10, in this phase, the automatic suitable questions obtained from the database suitable are: For a given element X, does X belong to class /subclass/ super-class Y? A software module will be the responsible for this part of the sequence of learning.
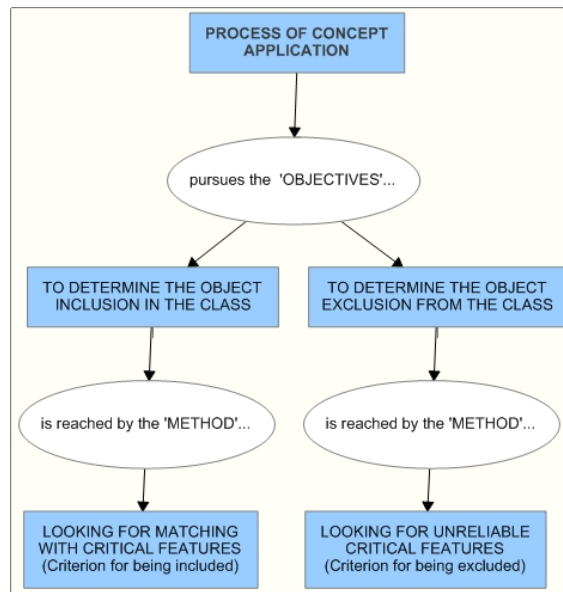

Fig. 11. Process of concept classification

4. Didactic networks for procedure application

4.1 Presentation

In BMI [6] a procedural task is basically a sequence of physical or mental actions. It can be a linear procedure or a branching one that can be interpreted as so many linear procedures as combinations of possible branches. But a procedure can be seen in a more generic point of view, as a set of non-sequential productions (rules) which, depending on preconditions, are enabled or disabled [2]. The methodology suggests a presentation showing the dimensions of divergence, an exemplification and practices. Adapting the general procedure definition, our proposal is based on the following steps:

1. Presentation of the procedure application, with two options and three networks.

- Sequential Procedure (see procedure presentation, fig 1).

- General Procedure. It is the transcription of the general complex problem-solving studied in the ACT-R theory of Anderson.[2], including both sequential as well as rule based procedures.
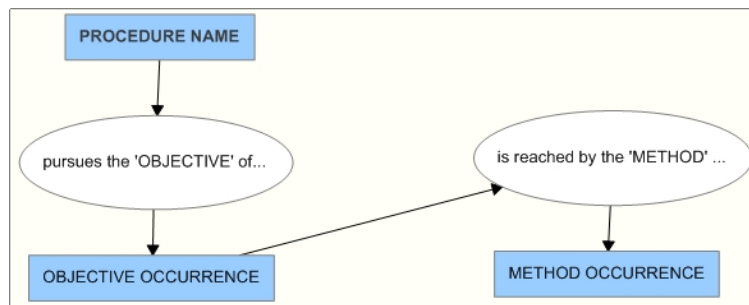

Fig. 12. General procedure presentation

- Method: The method is a relevant part of the procedure network, and it is important enough to be treated independently in order to be reused, because it is used often.
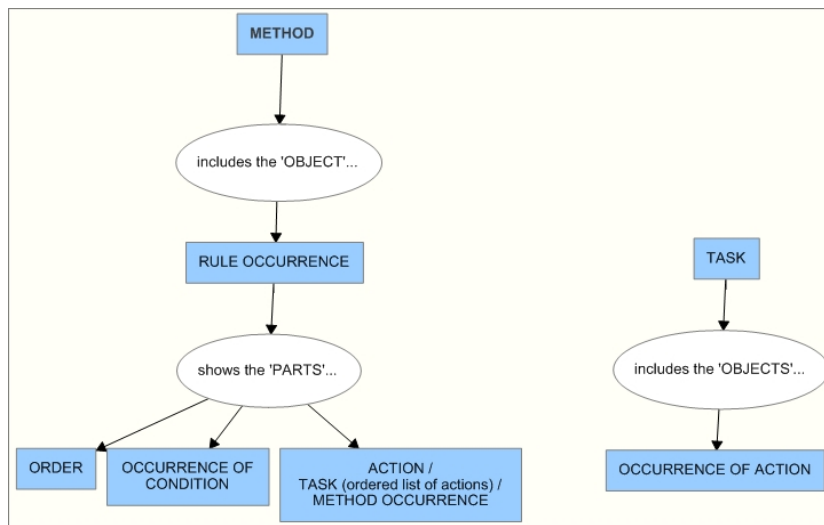

Fig. 13. Method presentation

4.2. Dimensions of divergence

Dimensions of divergence represent the different ways to solve a problem depending on different constraints, such as simplified methods, see Fig 15.

One of the most common examples for the dimensions of divergence is the simplified method for solving the determinant of a 2x2 or a 3x3 matrix. Fig 16. Shows the presentation of the corresponding didactic network.
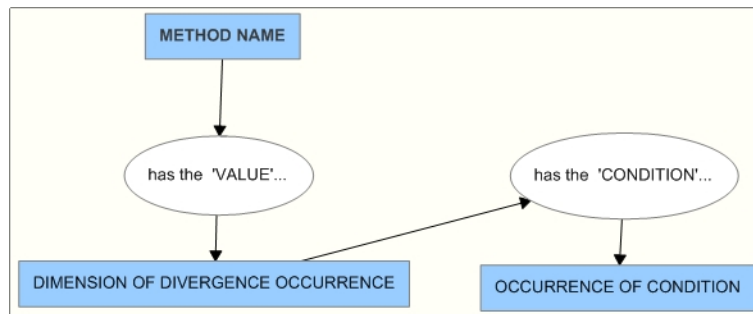

Fig. 14. Presentation of Dimensions of Divergence

4.3 Exemplification of the use of the procedure.

Demonstration of the use of the procedure rules for a specific set of data, by using the procedure presentation with a set of concrete data
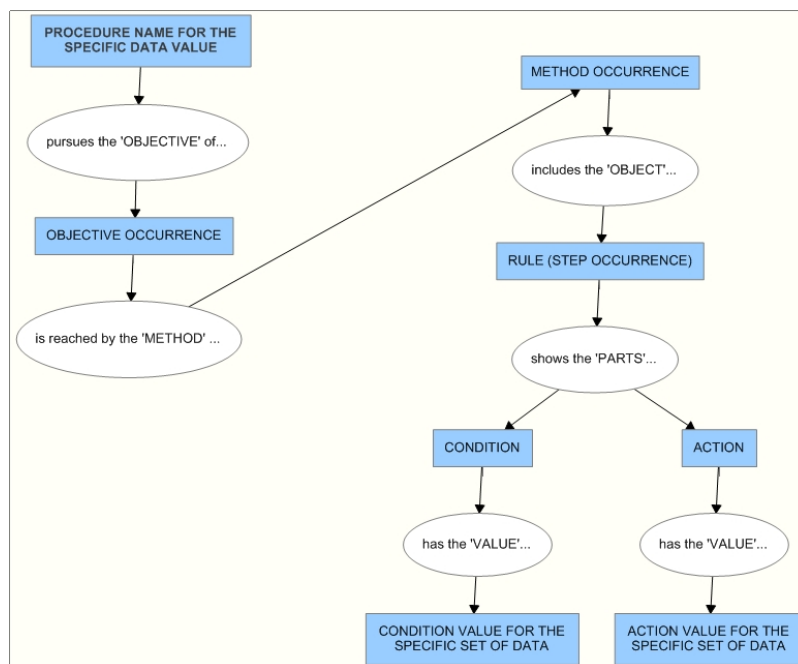

Fig. 15. Procedure exemplification didactic network

4.4 Test phase support.

It is based on automatically generated questions about the procedure use, such as "what is the first step?", "what is the next step to do?" or "what is the condition for an action?"

4.5 Practice and Simulation.

In some cases it is interesting to generate the same kinds of questions over different sets of data. A software module will be the responsible for this part of learning.

5. Didactic networks for principle application (classification)

Applying natural principles implies generalization and prediction of new cases. For causal principles there are two phases (acquisition and application) and three behaviors: Prediction, Explanation and Solution. The proposed method for learning principle applications based is:

1. **Presentation**. (causes and effects or sequence of events for natural principles)
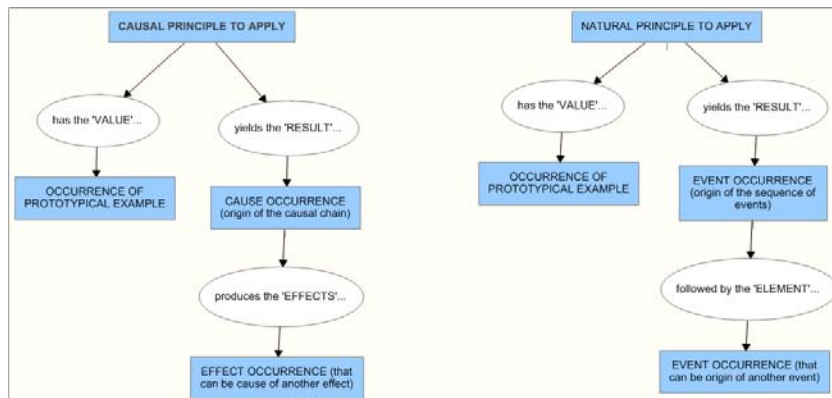

Fig. 16. Presentation of principle application

2. **Exemplification** of applications (as divergent as possible)

3. **Demonstration** by using divergent examples on the same didactic network

4. **Test and practices**. automatic questions: what is the cause/effect of ----?

6. Future research lines

Different research lines in which we are intensifying our activity are opened today, pointing in different directions. First of all, our main objective is to go deeper into the understanding and development of the theoretical framework, by means of:

- The formulation of a molecular structure of knowledge by using the patterns often used. (Fundamental Cognitive Networks and DNs for Understanding).

- Developing visualization patterns for web transformation design.

- Operations on RSR (plurals, inverses, combinations, verbal tenses, synonyms).

- After completing the knowledge model definition, a computing data model will be the main issue both for interchange and storage objectives, consisting of:

- The creation of an interchange computing data model both for representation and storage objectives, able to support FCNs and DNs.

- Software selection / development for e-learning generation and compatible tools.

- Definition of tests, practices and simulations.

- Elaboration of a Knowledge Representation Methodology, by using KNs.

References

1. Merrill, MD: Component Display Theory, in CM Reigeluth (Ed). Instructional-design theories and models. An overview of their current status, pp 279-333. Hillsdael, NJ: Lawrence Erlbaum Associates. (1983)
2. Anderson, John R, Lebiere, Christian: "The Atomic Components of Thought". Lawrence Erlbaum Associates, Inc ISBN 0-8058-2817-6. (1998)
3. Mann, William C. and Thompson, Sandra A: "An Introduction to Rhetorical Structure Theory". (1999)
4. Martinez, Raquel, Alamo, F. Javier del: "Sistema de Autoformación en el Método de Determinación de los Valores y Vectores Propios de un Operador". I. Congreso de Computación Simbólica ICE UPM. Madrid.(2003)
5. Novak, Joseph and Cañas, Alberto: "The theory underlying Concept Maps and how to construct and use them". (2006)
6. Reigeluth, Charles: "Basic Methods of Instruction". Indiana University Website. http://education.indiana.edu , http://www.indiana.edu/~ist/faculty/reigelut.html. (2007)
7. Alamo, F. Javier del. PhD Thesis: "Knowledge Modeling and Automatic Web exploitation". Polytechnic University of Madrid, Industrial Engineering School. Madrid (2007)
8. Alamo, F Javier del, Martínez, Raquel and Jaén, José Alberto: "Rhetorical-Semantic Relations: A proposal for Atomic Representation of Knowledge". ITA 09. Wales (2009)
9. Alamo, F Javier del, Martínez, Raquel and Jaén, José Alberto: "The intelligent web". ICAART. 2010. Valencia, Spain. (2010)
10. Alamo, F Javier del, Martínez, Raquel and Jaén, José Alberto: "Didactic Networks: A proposal for e-learning content generation". EISTA 2010. Orlando, USA. (2010)