

## ARK.I.NET, A GENERAL PURPOSE ENVIRONMENT TO SUPPORT THE COLLABORATIVE CONSTRUCTION OF KNOWLEDGE

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**Abstract.** ARK.I.NET, Architectural Knowledge in the NET, is a general purpose learning environment, which enables a group of users to construct knowledge in collaboration. ARK.I.NET's building blocks are concepts, themes and relations. The environment has been designed to foster the collaborative dimension in knowledge construction. Concepts can be defined in multiple ways; themes are set forth by grouping concepts from different users; and concept maps are built collaboratively, relating concept definitions and themes. It has been applied for the first time in a Ph.D. course, the interdisciplinary approach and constructivist methodology of which made it particularly suitable to unfold the pedagogical potential of the system.

### 1 Introduction

Since the academic course 1999-2000, in the course SDR: Sistemas de Representación we have been applying concept mapping tools in a collaborative scenario. These tools are part of a comprehensive web-based learning environment developed by the pedagogic research group ARC Arquitectura i Enginyeria La Salle especially for this course (<http://www.salleurl.edu/sdr/info>). In this environment, students analyze manifestoes of modern art and architecture, creating a vocabulary of critical concepts and collectively constructing a concept map which embodies the collective knowledge generated by the class (Madrazo et al. 2002).

This experience with concept maps convinced us of their pedagogic value, and motivated us to create a more comprehensive environment to support collaborative construction of concept maps, we named it ARK.I.NET, Architectural Knowledge in the Net. The goal was to provide a comprehensive tool that would facilitate the construction of knowledge to a group of students. The focus would be placed on the structuring of knowledge, in its architecture, and not so much on a specific subject matter (e.g. art, literature). From the technical standpoint, the goal was to enhance the capacities of the previous tool, building a stand-alone application, which would be platform independent and accessible through the web.

### 2 ARK.I.NET: Components

ARK.I.NET is a learning environment, which enables a group of users to participate in a collaborative process of knowledge construction, using concept map tools.

The architecture of the system is composed of three elements: concepts, themes and relations:

1- CONCEPT, a set of definitions identified by a name. A concept definition is the smallest block, from which other elements are formed.

$$C_n [D_1, \dots, D_m]$$

2- THEME, a set of concept definitions that make a conceptual domain.

$$T_n [C_i D_j]$$

3- RELATION, a link between two concept definitions. A concept map is the result of the manifold relationships amongst concept definitions created by the users of the system.

$$R_n [C_i D_j - C_i D_j]$$

In Novak's *Learning How To Learn*, a concept is defined in the following terms: "We define *concept* as a regularity in events or objects designated by some label" (Novak, 1984, p.4). Novak's concept definition focuses on the denotative dimension of language: concepts as labels designating objects, or properties of objects. In ARK.I.NET, on the other hand, the connotative dimension of language is mostly stressed: concepts are not mapped to objects, but rather they are endowed with meanings along the process of knowledge construction.

These three elements -concepts, themes, and relations- are the building blocks for constructing knowledge collaboratively. The construction follows an ordered sequence, moving from the simplest element -a concept definition- to the most complex one -a concept map, made up of relations and intertwined themes. This notwithstanding, there are alternative ways to put together the three basic elements. For example, it is possible to introduce a new concept while navigating across the concept map. The different possibilities to use the three basic components in the construction of knowledge are represented in Figure 1. In (a) a theme is created from existing concepts; in (b) a relation is established between two existing concepts; and in (c) a new concept is created in the process of forming a relation.

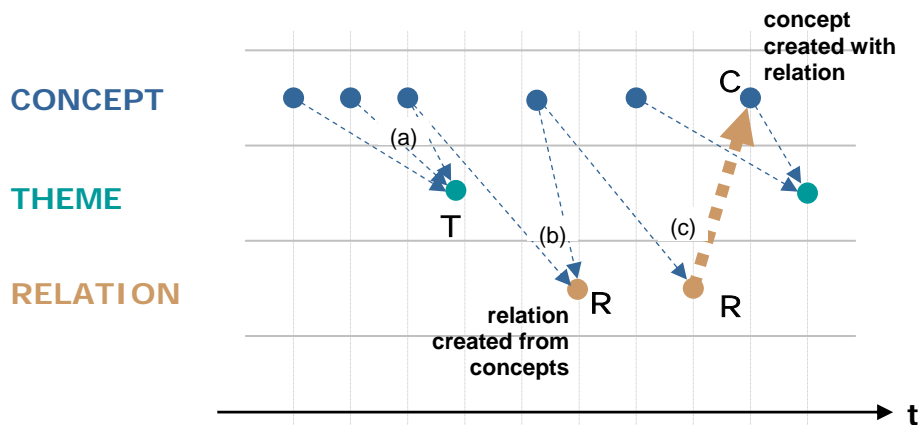


Figure 1. Concepts can be created before themes or relations or, they can be created at the same time.

### 3 ARK.I.NET: Structure of the System

This threefold structure, based on concepts, themes and relations, is reflected in the design of the interface. It is composed of three modes: CONCEPT mode, THEME mode and RELATION mode. Besides, there is a SYSTEM mode which informs about the activity of the system.

#### 3.1 CONCEPT Mode

In the CONCEPT mode, users collaboratively create the smallest elements -the concepts- with which themes or relations are to be created. Each concept is made up of a set of concept definitions, numbered by an index (e.g. 'Form[1]', 'Form[2]', .....make the concept 'Form'). The attributes of a concept include: name, definition, topic, source, user and date. This would be an example of the CONCEPT FORM, as defined by students using ARK.I.NET in a Ph.D. course dedicated to oppose the thinking of architects to the thinking of philosophers (see Section 5 below):

- Form[1]: "Appearance and manner to order a thought".*
- Form[2]: "What does not exist by itself".*
- Form[5]: "The language of things".*

These definitions are not meant to be taken from a dictionary. Rather, they are notions of form derived from lectures, and expressed with students' own words.

The CONCEPT mode has two distinct interfaces: 1. to list all concepts 2. to know about a selected concept in-depth. The table to list concepts is built block by block, as the user selects some of the attributes of a concept (Figure 2). For instance, by selecting the attribute 'user', the table would only show the concepts introduced by the selected user. If we then select the attribute 'topic', it would append to the previous block the list with the concepts sharing the selected topic. This way, the user can build a table at will, each block made up of a subset of the vocabulary.

Concepts can be created inserting a new entry on the same table. They can be edited or deleted, providing that they have not been included in a theme or a relation by another user. Also, it is possible to move across

modes, selecting a concept and taking it to the mode THEME or to the mode RELATION to construct a higher order entity with it.

To be able to get a thorough information about a concept, this has to be selected in the table and carried on to the second interface (Figure 3). In this interface, it is possible to read all of the definitions of the selected concept, or, alternatively, list all of the themes and relations where a selected concept definition is intervening. This way, we can quickly get an overview of the relevance that a particular concept is acquiring in the collective knowledge construction process. It also serves as a navigation map to move quickly to the other two modes, by clicking on the name of the theme or the relation which a concept definition is part of.

NOMBRE	DESCRIPCIÓN	AUTOR	FUENTE	USADO	FECHA
forma [1]	Ordenamiento y modo de ordenarse un pensamiento.	Wittgenstein	Tractatus	3.111	2002/12/21
forma [2]	Es el objeto de nuestro trabajo, sino sólo el resultado.	Heidegger	Meas - Escritos, dial.	F. C. 101	2002/12/21
forma [3]	No existe por sí misma.	Heidegger	Meas - Escritos, dial.	F. C. 101	2002/12/21
forma [4]	esencial constitución interna de un objeto, que aparece.	Heidegger	Carlos Martí	F. C. 101	2002/12/21
forma [5]	aparición del objeto, aspecto o conformación externa.	Heidegger	Carlos Martí	F. C. 101	2002/12/21
forma [6]	lingüístico de las cosas.	Wittgenstein	Trp	A. Calvo	2002/12/21
forma [7]	RAZÓN DE SER.	Foucault	SANTO DOMINGO	F. C. 101	2003/03/23
arte [1]	Es una interpretación, que siempre tiene utilidad.	Calderon	Andreu Marqués	G. Ham	2003/02/27
autenticidad [1]	Para Calderon y para Heidegger. Concepto. Para Calderon, no.	Calderon	Elvira	R. Miralles	2003/02/27
habitar [1]	Es la solución a los problemas del mundo. Con una luz.	Calderon	Verdad y Método	R. Miralles	2003/02/27
simpleza hermeneutica	emoción estética.	Calderon	Carlo Sini	E. Hernandez	2003/03/10
comprensión [1]	pretensión de entender lo que nos ha sido transmitido.	Calderon	Verdad y Método	R. Miralles	2003/04/23
espejo del creador	Es lo que desea transmitir al que crea algo, pero se es.	Calderon	conocencia historica	R. Miralles	2003/04/23
esteticismo [1]	actitud que sólo busca un placer superficial en el arte.	Calderon	S. N.	R. Miralles	2003/02/27
ética [1]	es uno de los pre-supuestos básicos en filosofía. En el	Calderon	ep. de la	R. Miralles	2003/02/27
expresión personal	Es el que quiere, subjetivo, pero una verdad al fin y al cabo.	Calderon	Conocencia historica	R. Miralles	2003/04/23
hermeneutica [1]	Es la filosofía actual de arte y arquitectura. Es el arte.	Calderon	Andreu Marqués	G. Ham	2003/02/27
hermeneutica [2]	Arte de interpretar.	Calderon	Elvira	R. Miralles	2003/02/27
historicismo [1]	Es la comprensión propia de la historia.	Calderon	Andreu Marqués	G. Ham	2003/02/27
interpretar [1]	Es decir, conocer y saber hacer.	Calderon	Andreu Marqués	G. Ham	2003/02/27
interpretar [2]	comprender a partir de prejuicios.	Calderon	Andreu Marqués	E. Hernandez	2003/03/10
interprete [1]	es el medium entre el significante y el significado.	Calderon	Duchamp	R. Miralles	2003/04/23
lingüístico [1]	Es uno de los pre-supuestos en filosofía. En lenguaje.	Calderon	Wittgenstein	R. Miralles	2003/02/27
metodo [1]	Es el trabajo y en él se resuelve los problemas que	Calderon	S. N.	R. Miralles	2003/02/27
pensar [1]	Es dialogar.	Calderon	Andreu Marqués	G. Ham	2003/02/27
prejuicio [1]	lingüístico, condición a priori de la comprensión.	Calderon	Andreu Marqués	E. Hernandez	2003/03/10
prejuicio [2]	estructura previa.	Calderon	Andreu Marqués	E. Hernandez	2003/03/10
prejuicio [3]	condiciones espacio-temporales del sujeto, memoria o	Calderon	Andreu Marqués	E. Hernandez	2003/03/10

Figure 2. CONCEPT mode. Table to visualize the vocabulary.

CONCEPTO: forma [1]: Wittgenstein

forma [1] — objeto [1] (G. Ham)

Figure 3. CONCEPT mode. View of single concept.

### 3.2 THEME Mode

In the THEME mode, concept definitions are grouped to create higher order entities named themes. The purpose of this mode is to create new conceptual domains by grouping concept definitions. These domains provide a context where concepts acquire a more concrete meaning. Somehow, a theme can be understood as a concept map with no explicit relations among them.

To create a theme, the concept definitions are selected from the existing vocabulary and dragged onto the main window (Figure 4). The vocabulary, which appears on the left column, can be filtered by attribute to reduce the number of entries a user might want to work with. Once the concepts are in the working area, their attributes can be edited (spatial position, color, and font). With these attributes concepts get more expressiveness, making them more intelligible and meaningful to others (Wallace et al., 1998). The theme, that is to say, the context which gives particular meaning to the selected concepts, is defined by the user with a short text. Also, it is necessary to describe the relationship that each selected concept holds with the suggested theme.

In order to make it possible for the user to work on the creation of a theme during several sessions, the work-in-progress can be saved in an individual working space (I-Workspace) to be published later (e.g. made available to all other users).

If during the process of creating a theme, a user realizes that it is necessary to define a concept which is not in the vocabulary, it is not necessary to move to the CONCEPT mode to do it. The CONCEPT definition procedure can be invoked without leaving the THEME mode. This way, these two modes -CONCEPT and THEME- become interwoven during the process of knowledge construction.

Already defined themes can be visualized in the same interface, after switching to the visualization sub-mode. Then, the names of existing themes are listed on the vertical column. To reduce the number of elements in the list, themes can be filtered by user name or by the concepts that they contain. A particularly powerful feature, enables the user to fix a concept that will serve as a vector traversing a set of themes created by several users, all of them sharing the selected concept (Figure 5). To move from one theme to another along this vector, it is enough to drag the cursor on a slider. As we move the cursor, the themes appear and disappear, merging one with the other, suggesting new ways to group concepts (e.g. new themes). Thus, moving from one theme to another becomes an opportunity for knowledge discovery in a collaborative scenario. At any moment during this

navigation through the existing themes, a user can save the information being displayed on the screen, to be recovered later.

To have an overview of all existing themes, there is a table that can be built by the user, in much the same way as the table in the CONCEPT mode. Blocks of themes are displayed after selecting one of its attributes (name, description, concepts, user and date). A theme can be selected from this list to create a new theme out of it. From the point of view of collaborative thinking, this is a particularly powerful feature, since it allows users to create a chain of themes.



Figure 4. THEME mode. Interface to create/visualize a theme.

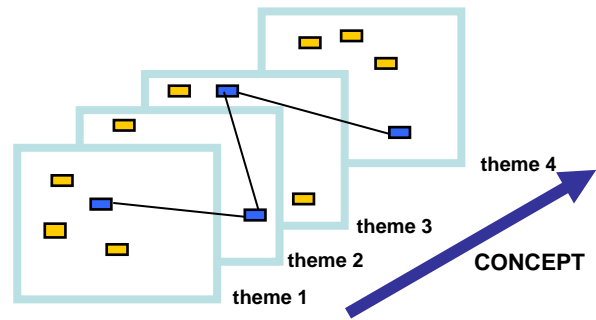


Figure 5. THEME mode. Navigation through the themes.

### 3.3 RELATION Mode

In ARK.I.NET, a RELATION is a description of the link between two concept definitions, as described by the user. There is no distinction between concept words and non-concept words, as in Novak's concept maps, where the first ones are thought of as concept labels and the second as links.

A user can establish any number of relationships between any pair of concept definitions. All these relationships are recorded by the system, and then represented as a concept map. The visualization of the concept map becomes a construction process: as the user explores paths in the net of concepts, the structure of connected concepts is formed (Figure 6).

In ARK.I.NET, relations between two concepts can be dyadic or triadic (Figure 7). In the dyadic mode, the link between two concepts is described by means of a text. The triadic structure evokes Pierce's semantic triangle, where the *representamen* and the *object* would lie at the bottom, and the *interpretant* at the vertex (see Sowa's *Knowledge Representation* for a discussion on dyadic and triadic structures in conceptual graphs). However, in our triadic structure, a sign is not related to the object -as in Pierce- but rather there are two *representamen* (e.g. two concept definitions) at the base of the triangle. In this context, the third concept sets up some limits to the universe of meanings that the relations between the other two might bring about. Such triadic structure can be understood as a reduced theme, made up of only two concepts, the third one being the label for the theme.

As in the THEME mode, in the RELATION mode there are also three kinds of interface: 1. to create a relation 2. to visualize the existing relations as a concept map and 3. to list the existing relations.

The process to create a relation is very intuitive. In the corresponding interface concepts are selected and dragged onto the working area. Then, in order to establish a relation between two concept definitions, it is enough to pick and drag one node over the other. As a result, a line connecting the two nodes is displayed, and the user is prompted to explain the relation with a short text. In much the same way as with the mode THEME, the user has the option to save the relation in the individual working space (I-Workspace) to be published at a later time.

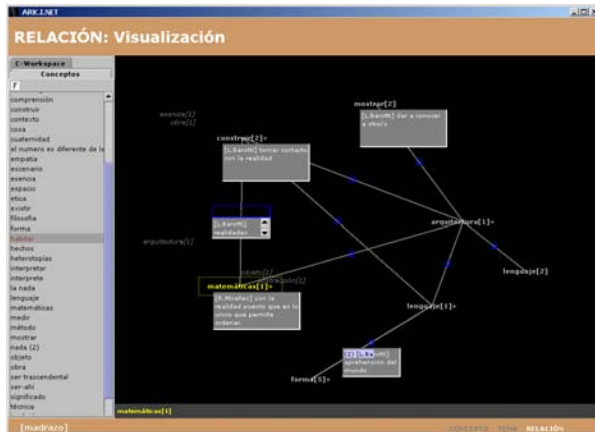


Figure 6. RELATION mode. Interface to creation relations.

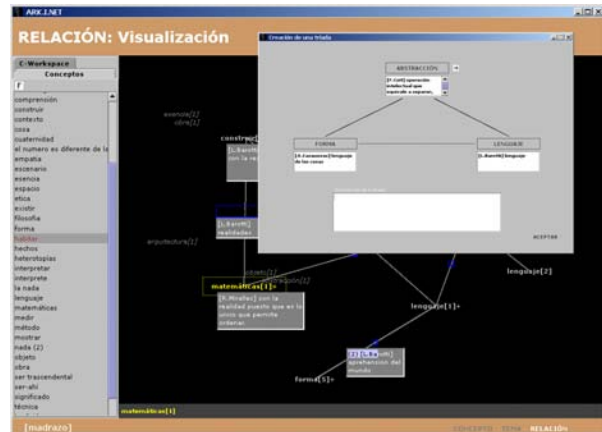


Figure 7. RELATION model. Triad connecting three concepts.

To visualize the network of existing relationships as a concept map, it is necessary to change to the visualization sub-mode. At the outset, a concept is selected from the list on the left column and dragged onto the working area. This concept becomes the focus node of the portion of the concept map to be displayed. The '+' sign appended to the concept indicates that there are other concepts related to this. As we click on a node, the related concepts are displayed. The process of opening up nodes can be repeated up to three times for a given portion of the map. Then, to continue navigating further, the focus node needs to be replaced. All focus nodes selected in one session are recorded in a history line, so that the user can recover an area of the map by clicking on one of the visited nodes.

Relationships between concepts are visualized as lines with a node at the center. Only one relation between two pairs of concepts is displayed, although there might be many relations established between the two. If this is the case, a '+' sign appears in the node placed at the middle of the connecting line. Then, the user can select one of the existing relationships to be displayed.

While users navigate through the concept map, the process of building relationships continues. For instance, a user can add a node to the currently displayed portion of the concept map, simply dragging a new concept to the working area. Also, a user can create triadic relationships by adding a third concept to an existing relation, directly on the concept map. If in the course of navigating through the map a user recognizes the need to create a new concept, the CONCEPT creation procedure can be called up within the RELATION mode.

As concepts in the map might be also part of a theme, it is possible to display the set of concepts that share a theme with the selected node. After clicking on a node, a myriad of concepts appear around it, suggesting possible intersections between the group of concepts making a theme and those making the concept map.

Particularly important, for the collaborative construction of knowledge, is to switch to a collaborative working mode, which enables the user to store the current portion of the concept map, label it and comment it. This way, other users can later retrieve these reflections as they navigate through the concept map. Also, these partial views of the map are useful to be shown and explained in the class discussions.

Consistently with the other two modes, there is also an interface where all existing relations are listed as a table constructed by the user. The entries can be edited by the owner, providing that no other user has made use of them. Also, as in the CONCEPT and THEME tables, an item from the list can be selected to be modified or to create a new one from it; in this case, a new relation.

### 3.4 SYSTEM Mode

Besides the three structural modes, there is a fourth one for the user to get easily oriented throughout the flow of information produced by the system. As the user logs in, a screen shows the activity of the system, at the individual and collective levels, week by week (Figure 8). The area on the left shows the records of the actions done by the user (e.g. defining a concept, creating a theme or relation,...). The right side is divided into three rows, each one displaying the activities of a user concerning concepts, themes and relations, for each week during the system activity.

With this mode, the user gets a quick overview of the system activity: which concepts are being defined, which themes are being proposed, and which relationships are being established. By clicking on one of the items, we move to the corresponding mode, carrying with us the selected item. For instance, if we are interested in a relation that a user has established between two concepts, by clicking on the relation this will be visualized in the RELATION mode.

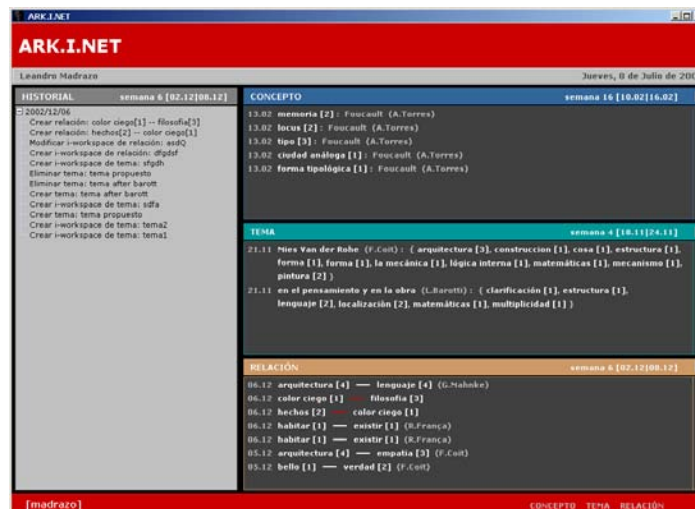


Figure 8. SYSTEM mode.

#### 4 Concept Maps and Knowledge Maps

Distinctions between concept map, cognitive map, semantic network and knowledge map are sometimes hard to establish. According to Novak, “Concept maps are intended to represent meaningful relationships between concepts in the form of propositions” (Novak, 1984, p.15). As ARK.I.NET is not meant to represent propositions made up of concept words connected by non-concept words, it might not be called a concept map. Concept maps that are meant to represent an individual’s knowledge are referred to as cognitive maps (Sherratt et al., 1990). Since ARK.I.NET is a collaboratively constructed concept map, it might not necessarily be a cognitive map, although users can see their thinking structure represented in it, to some extent. A semantic network, according to Sowa, is “a graphic notation for representing knowledge in patterns of interconnected nodes and arcs....a declarative graphic representation that can be used either to represent knowledge or to support automated systems for reasoning about knowledge”. ARK.I.NET does not have the inner declarative logic of such semantic networks. Finally, the term knowledge map is sometimes used for concept maps which help a community of learners to derive knowledge from them in collaboration (Lambiotte et al. 1989). In this sense, the term knowledge map would be the most adequate to describe ARK.I.NET. Nevertheless, we have used concept map throughout the whole text, because of its generality.

#### 5 Pedagogic Application

ARK.I.NET provides a ‘neutral’, language-based structure that allows a group of users to construct knowledge using linguistic blocks, regardless of the subject matter at stake. In order to test the validity of the tool -from the conceptual and the functional point of view- we used it in a Ph.D. course named PENSAMIENTO:FORMA (<http://www.salleurl.edu/arq/plaestudis/doctorat>), in the academic year 2002-03.

The purpose of this course was to weave strands between architecture and philosophy. The series of lectures were structured into four blocks, each one dedicated to confront the ideas of a philosopher with the works and thoughts of an architect: Wittgenstein (philosopher) vs. Wittgenstein (architect); Heidegger vs. Mies; Foucault vs. Rossi; and Gadamer vs. Koolhaas. Each block consisted of three lectures, given by known specialists on each author.

Students were asked to summarize each lecture in a few concepts, to be introduced in ARK.I.NET. At the end of each block of lectures, they were asked to build themes, grouping concepts. The themes proposed were the contexts where concepts would be endowed with concrete meaning. These themes were then presented in the



classroom, using the interfaces of the THEME mode. As a final step, students were asked to create pairs of relationships between concepts, which then would be visualized as a concept map in the RELATION mode.

In this context, the concept map became both a representation of the collective knowledge gathered by the group and a generator of new knowledge. However, eliciting knowledge embedded in a concept map which has been collaboratively created marks the beginning of a complex social and intellectual process, rather than the endpoint of a knowledge construction process. As McAleese, has contended: "In the construction of conceptual maps learners will come to negotiate and modify what it is that they appear to know in terms of what is known". (McAleese, 2000). As a matter of fact, in the process of constructing a map with ARK.I.NET, the learner's own knowledge is confronted to the collective knowledge embedded in the map.

Our assumption was, that the isolated blocks of knowledge that students derived from each lecture would give rise to a collaborative construction of a subject-matter which was not laid out in any form (book, syllabus) before the course started. This way, a complete integration of content, methods and tools would be achieved. At the outset, it seemed a sound pedagogic strategy, backed by the successful experience of using similar but simpler environments in our undergraduate courses. However, the results from this first application were not as encouraging as we had expected. Participating in a collaborative process of knowledge construction -such as the one supported by ARK.I.NET- means a high intellectual level for all participants. Summarizing lectures in philosophy and architectural theory in a few concepts, describing them in a meaningful and suggestive manner, and being creative discovering relationships, demands a linguistic and cultural competence which not all students -even at the postgraduate level- possess. Moreover, working with concept maps representations requires a metaknowledge capacity which cannot be taken for granted even in postgraduate education. Eliciting knowledge from a concept map, in a multidisciplinary context, is a big challenge for all participants, students and teachers. Also, we must keep in mind that behind some of these difficulties lie issues which are still a matter of research, including: construction of meaning through direct manipulation of conceptual maps; the role of conceptual maps in the eliciting/structuring of knowledge; and the process of finding/discovering meaning through navigation in semantic spaces (Landauer et al., 2000; Gärdenfors, 2000).

## 6 Summary

We have developed a general purpose system, which can support collaborative construction of knowledge using language. This construction is based on three basic elements: concepts, themes and relations. This threefold structure is embedded in the user interface and in the modes of operating with the system. In order to have a pedagogic relevance, it is necessary to create the appropriate learning scenarios, where the potential of the system can be unfolded.

## 7 Acknowledgments

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