# We are IntechOpen, the world's leading publisher of Open Access books
# Built by scientists, for scientists

13

# Free Text Response Assessment System Based on a Text Comprehension Model

Panagiotis Blitsas[1] and Maria Grigoriadou[2]
[1] *Interdisciplinary Program of Graduate Studies in Basic & Applied Cognitive Science*
[2] *Department of Informatics & Telecommunications*
*National & Kapodistrian University of Athens*
*Greece*

## 1. Introduction

Nowadays, computer scientists make efforts to develop systems based on Cognitive Psychology and its theories (Kintsch, 1992; Kintsch, 2001; Rinaldi et al, 2002; Graesser & Tipping, 1999). Such systems have as their main goal the computer-assisted assessment of free-text responses and most of them are based on the Latent Semantic Analysis Theory (Landauer & Dumais, 1997), by using vector-oriented analysis. The need of diagnosing alternative conceptions presented in a free-text response, rather than just marking it, leaded to our knowledge-based system proposal.
This chapter aims to describe this system, which could give a boost to an automated free-text response assessment, by extending its knowledge base with new assessing rules, concepts and relations among them, and by diagnosing misconceptions presented in this response, according to the *Baudet & Denhière Text Comprehension Model*; this model describes the way a text reader constructs his/her mental knowledge representations during the reading process. Additionally, the present chapter introduces Semandix, which constitutes a semantic tool implementing two of the basic modules of the proposed system upon the precious contribution of concept mapping tool and computational semantic dictionaries.
In detail, section 2 describes the *Baudet & Denhière Text Comprehension Model*, while section 3 presents the necessary semantic tools for an automated assessment system. In sections 4 and 5 we explain the design of the proposed system and introduce Semandix, respectively. Finally, in section 6 our future plans are being discussed.

## 2. Text Comprehension Model

For the representation constructed by learners during the comprehension process of a text, primary role should be attributed to the understanding of the cognitive categories: entity, state, event and action (Baudet & Denhière, 1992; Lemaire, Denhière et al, 2006). The term entity refers to the atoms, units or persons participating in the representation structure. The term state describes a situation in which no change occurs in the course of time. The term event refers to an effect, which causes changes but is not provoked by human intervention.

The event can be coincidental or provoked by non-human intervention, e.g. by a machine. An action causes changes but is originating by a man. Text comprehension is considered as the attribution of meaning to causal relations between occurrences in the text. Learners construct a representation of the text, which contains the cognitive categories: entity, state, event and action. For the interpretation of learners' cognitive processes their discourse is analysed, in order to trace the recognition (or not) of the cognitive categories.
Furthermore, text analysis in relation to the cognitive categories does not suffice (Baudet & Denhière, 1992). The organization and structure of cognitive representation should involve three structure types: relational structure, transformational structure and teleological structure. The *relational* structure represents a state in which there are entities of the possible world and no change occurs in the course of time, whereas part/all relations define a hierarchy in the structure of the system. The *transformational* structure represents complex events of the world or events sequences, which provoke transformation of static states. When a transformational structure is causal then it is described as a causal path among events. When it is temporal the changes are temporal and not necessarily causal. Part/all relations among events and macroevents define a hierarchy in the system. The *teleological* structure is organized in a tree of goals and/or subgoals and within a time period its initial state, defined by the present entities, their relations and the values of their properties, changes turning into a final state performing in that way the predefined goal.
The organization and structure of cognitive representation should also be examined on micro and macro-level. On the micro-level scale, the creation of a text that allows a precise description of a technical system and facilitates readers in constructing its microstructure representation must involve the description of (i) the units that constitute the system based on the causal relations which unite them and (ii) the events sequence taking place on these units in respect to causes affecting them as well as to changes that bring the system from one state to another. On the macro-level scale, the development of the macrostructure by readers is achieved through the reconstruction of the microstructure and the establishment of a hierarchical structure with goals and subgoals. The creation of a text, which facilitates readers in constructing its macrostructure representation for a technical system, must involve the teleological hierarchical structure of goals and subgoals of the various operations as well as their implications. A technical system containing a set of associated units, which are fixed by hierarchical relations of all/part-of type and can be organized as a tree of goal/subgoals is called a Functional System.

## 3. Semantic Tools

### 3.1 Concept Mapping

In educational settings, concept mapping is a teaching and learning valuable tool providing an explicit learners' knowledge structure representation and promoting meaningful learning (Novak & Musonda, 1991; Novak & Gowin, 1984; Blitsas, Papadopoulos et al, 2009). A concept map is a set of nodes, which represent concepts and relations among concepts. The concepts and relations are organized into hierarchical, circular or hybrid structures as a whole so as to represent and describe the central concept of the map, which is the root of the node. One of the key tools is the CMapTools http://cmap.ihmc.us/ (Figure 1), which enables the user to export the concept map created in the form of XML file.

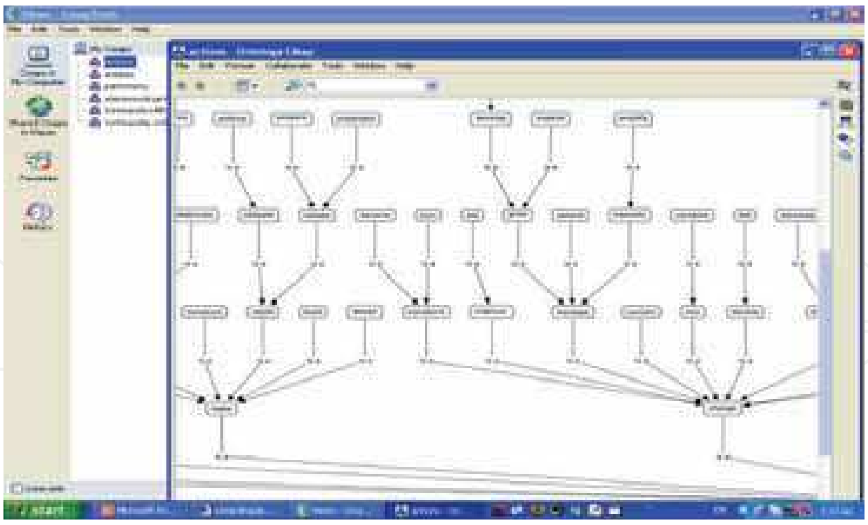


Fig. 1. CmapTools software

### 3.2 "Machine Readable" Dictionaries

Electronic dictionaries commonly used nowadays are in fact printed dictionaries converted to electronic form, so that they can be easily searchable through a computer. The computational lexicons or "machine readable" dictionaries have completely different function. They include, apart from definitions and examples of the words/entities use, relations among these words. Their creation is resulted by the need of use in applications in the field of Linguistic Technologies, such as "Machine Translation", "Information Retrieval & Extraction from Corpora", "Construction Summary" etc. Most of these dictionaries do not rely on text comprehension models but merely on language use standards (grammar rules, multilingual terms recognition etc.), statistical modeling (use of word frequency, cohesion etc.) or a combination of these two. In this section an overview of the principal computational semantic lexicon Wordnet and Visdic platform is presented.

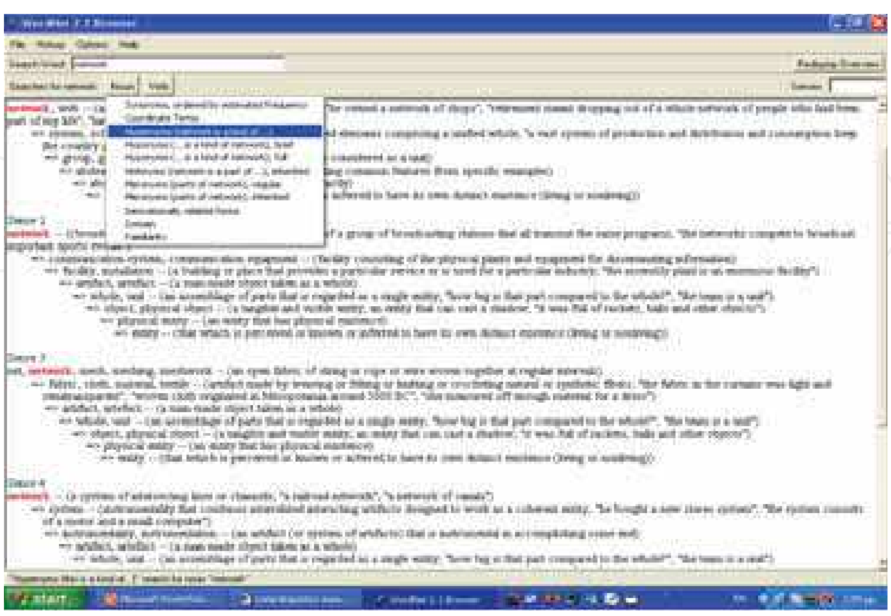


Fig. 2. English Wordnet Environment

Wordnet (Figure 2) is a computational semantic lexicon organized semantically and containing essentially verbs, adjectives and adverbs grouped into sets of synonyms (synsets). A synset is a set of words, which in a given environment may be used in place of one another. Another important feature of Wordnet is the separation of concepts in fields (domains). A word may belong to several synsets in many domains. Each synset in each domain has its own interpretation by examples and semantic correlations of hyperonym, hyponym, olonym, and meronym with other concepts. For example, the word "memory" is presented in separate wordnet synsets in Psychology & Computer Science domain.
Visdic editor http://nlp.fi.muni.cz/projekty/visdic/ (Figure 3) constitutes a graphical application for browsing, editing or linking "machine readable" dictionaries in different languages and structured in XML format.

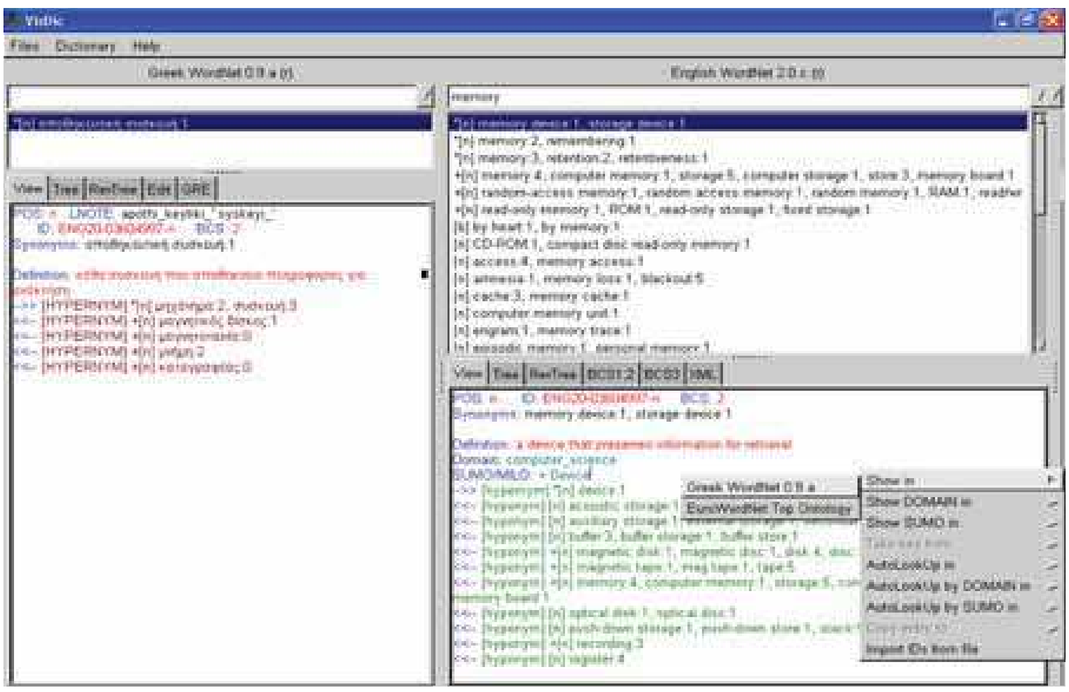


Fig. 3. Visdic Editor Environment

## 4. Designing a Free-Text Response Assessment System

In this section we present the design of a proposed Free-Text Response Assessment System based on Denhière-Baudet Text Comprehension Model and some examples of implementing this system in terms of Prolog facts (Blitsas & Grigoriadou, 2008). Figure 4 displays the architecture of that system.
In detail, the four basic system modules, described in the next subsections, are the following:

- Normalization Module (NoM): convertion student's free-text response into normalized response through Natural Language Processing (NLP)
- Functional System Module (FSM): ontology of the basic structures of the expert's knowledge representation, namely relational and transformational structure of microstructure, and teleological structure of macrostructure, depicted in the expository text referring to Computer Science domain.

- Enrichment Module (EnM): enrichment of the system Knowledge Base with content from expository texts, concept maps and/or wordnets (XML format).
- Assessment Module (AM): assessment of normalized response coming from NoM.

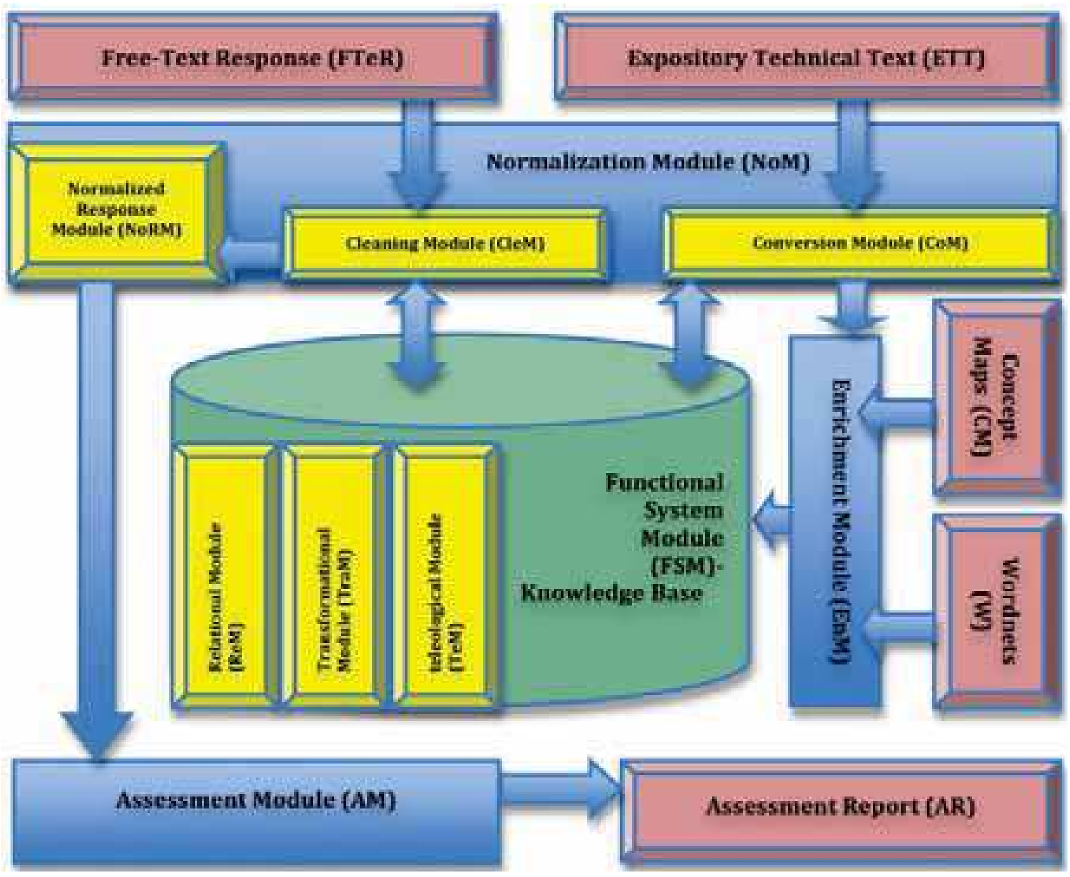


Fig. 4. Architecture of the Free-Text Response Assessment System

### 4.1 Normalization Module (NoM)

Its goal is converting a free-text response into normalized response referring to Computer Science domain into ontologies, describing the microstructure and macrostructure, enriching the content of FSM, which is being described in subsection 4.2.
When we use the term 'normalized response', we mean the response, which includes the entities, meaning the units, the events and the macroevents, declared explicitly or implicitly in the respective free-text response. In order to achieve the previous goals, the Normalization Module has the following three submodules:

- Cleaning Module (CleM): It is responsible for cleaning up the student's free-text response from unnecessary words. Collaborating with the FSM it can “decide” which word will be cleaned up and which one will be kept as necessary. It means that when CleM meets a word that constitute entity or relation, appeared in FSM, it will keep this word, and additionally, it will build the representation of student's response. This representation is, in fact, the 'normalized' response. The output of CleM is led, as an input, to NoRM. During this processing stage, there is a need for CleM to collaborate with computational synonym dictionaries, such as WordNet, in order to decide if a word is a synonym of an entity or relation of FSM, so that CleM keeps the word as a necessary one and does not consider it as irrelevant. This collaboration can be achived through EnM.

- Conversion Module (CoM): It is responsible for distinguishing the expository text entities, into units, events and macroevents, in order to send them to FSM where microstructure and macrostructure ontologies will be constructed.
- Normalized Response Module (NoRM): It functions as a buffer of the student's normalized response. Its output is led to AM for estimating the errors appeared in student's normalized response representation.

### 4.2 Functional System Module (FSM)

The Functional System Module includes three submodules, which depict the Relational Structure (ReM), the Transformational Structure (TraM) and Teleological Structure (TeM) of expert's knowledge representation. This module takes, as an input, the output of CoM, and constructs the different structures.

As an example for representing these three structures of expert's knowledge, we used a expository text, taken from the book 'Computer Science: An overview' (Brookshear, 2006). This text extract refers to the combination of bus topology networks toward forming wide area computer networks: *"The repeater is little more than a device that connects two buses to form a single long bus. The repeater simply passes signals back and forth between the two original buses (usually with some form of amplification) without considering the meaning of the signals. A bridge is similar to, but more complex than, a repeater. Like a repeater, it connects two buses, but it does not necessarily pass all messages across the connection. Instead, it looks at the destination address that accompanies each message and forwards a message across the connection only when that message is destined for a computer on the other side"*.

The expert's micro and macrostructure representations are following in subsection 4.2.1.

#### 4.2.1 Expert's microstructure representation

At the microstructure level, there is a description of units, which constitute the system, as well as, the causal relations, which connect them. First stage of realizing microstructure representation is constructing relational structure of the text content. Relational structure has two basic ontologies (Gruber, 1993): taxonomy and partonomy.

Taxonomy is a tree-like structure, 'is a' type, which analyzes the taxonomical relations among the entities appeared in the expository text. Partonomy is a tree-like structure too, 'part of' or 'has' type, which expresses all/part-of relations among the text entities. These ontologies have to represent the knowledge, explicitly referred in the text, as well as, the implicit knowledge, which is activated during the reader's comprehending. Examples of taxonomy and partonomy are following, in form of Prolog facts:

| | | | |
|---|---|---|---|
| ***Taxonomy:*** | is_a(repeater, device). | is_a(bridge, device). | is_a(bus, lan). |
| ***Partonomy:*** | part_of(node, bus). | part_of(lan, wan). | part_of(content, signal). |

Second stage of realizing expert's microstructure is representing transformational structure (figure 5).

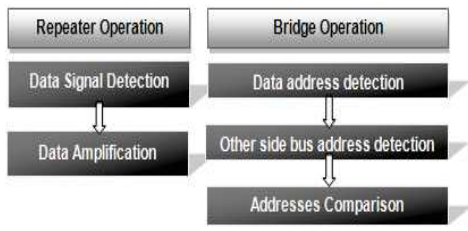



Fig. 5. Expert's Transformational Structure

#### 4.2.2 Expert's macrostructure representation

Expert's macrostructure includes teleological structure and microstructure. Teleological structure, describing in section 2, is depicted in TeM, and an example, referred to the text, is show schematically, in figure 6.

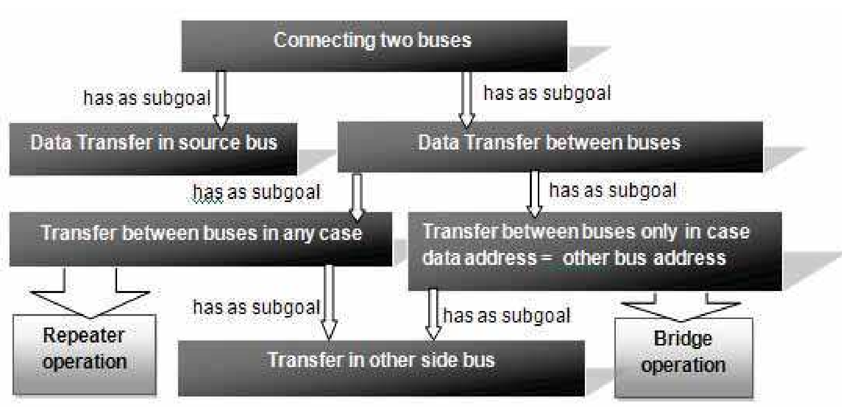



Fig. 6. Expert's Macrostructure

### 4.3 Assessment Module (AM)

The Assessment Module could assess three kinds of questions:

(i) Ontological questions, through ReM, such as 'what is',
(ii) Operation questions, through TraM, such as 'how does it work', and
(iii) Teleological questions, through TeM, such as 'why' or 'which one'

In order to develop the Assessment Module, we had to obtain data of errors students make, during reading expository text and answering questions on microstructure and macrostructure they construct. An experiment on secondary level students took place to estimate the alternative conceptions students have during comprehending technical expository texts.

Two question types were given to the participants:

- inference questions, examining the transformational structure students formed and
- bridging questions, examining the macrostructure they formed and the recall they achieved from different points of the text.

Forms for completing events (for the first question type), and choosing the right device for a specific goal (for the second question type) were given. So, the demanded responses had a normalized form. One example question of each type is following in the next two subsections.

### 4.3.1 Response assessment on microstructure questions

An example of inference question, referred to transformational structure, which belongs to microstructure, is the following: *“Describe the operation of a Router, step by step, from the first state, in which the message is located in the source node of the source network to the state, in which the message is located in the destination node of the destination network”.*

Three error types were mentioned on students' responses:

- missing events in the events sequence
- events replaced by goals
- causal errors among events

The right sequence of events of Router operation (Router transformational structure) is:

*(destination network) protocol detection* → *protocol control* → *protocol comparison* → *protocol conversion.*

For example, in a student's response, the next error types were appeared:

- Causal error: instead of 'protocol control' precedes 'protocol conversion', in the response 'protocol conversion' precedes 'protocol control',
- Event replaced by a subgoal: in place of 'data detection', 'data transfer' appears.

Figure 7 displays the analysis of student's transformational structure assessment process, and figure 8 displays an example of automated transformational structure question assessment, implemented in Prolog. In figure 8, AErrors are “events replaced by subgoal” errors, and BErrors are the causal errors. Finally, MEvents are the missing events.

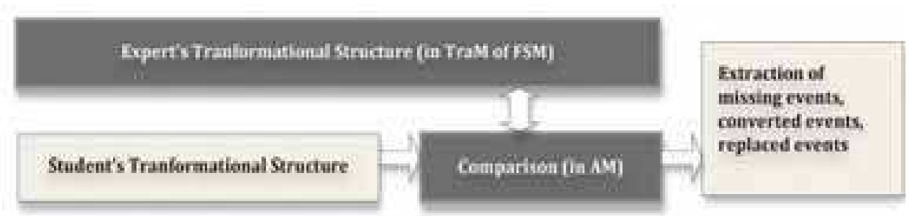



Fig. 7. Student's transformational structure assessment process

```
# 0.01 seconds to consult teleologia final.pl [c:\documents and settings\     \desktop\
| ?- seekerrors(AErrors,AErrorsAm,Right_Order,Wrong_Order,BErrorsAm,MEvents,MEventsAm).
Give the testing device:
|: router.
Give the events sequence:
|: control_protocols.
|: detect_protocols.
|: transmit_protocols.
|: convert_protocols.
|: exit.
AErrors = [transmit_protocols] ,
AErrorsAm = BErrorsAm = MEventsAm = 1 ,
Right_Order = [detect_protocols,control_protocols] ,
Wrong_Order = [control_protocols,detect_protocols] ,
MEvents = [compare_protocols] ;
```

Fig. 8. Automated transformational structure question assessment example

### 4.3.2 Response assessment on macrostructure questions

A bridging question demands a response after combining information from more than one point of the given text. An example of bridging question follows: *“In the case of connecting a Bus with a Ring topology network, which is the device, you have to use? Why the other devices are rejected? Justify your position”.* This question demands a position and justification for the choice of the right device and for the rejection of the others. The response is based on the macrostructure (including the microstructure of 'repeater', 'bridge', and 'router' devices). Router is not presented in the example text but is appeared in a bigger text, where the example text belongs.

The following incomplete sentences were given to the students:

*"The right device is ...(1) because ...(2)"*

*"Device .... (3) can't be used because ... (4)"*

*"Neither device ... (5) can be used because ... (6)"*

The right response is: (1) Router, (2) protocol conversion, (3) bridge or repeater, (4) not protocol conversion, (5) repeater or bridge & (6) not protocol conversion.

In students' responses, the following error types were appeared:

- Wrong position (1) or/and justification (2) for the choice of the right device.
- Wrong positions (3), (5) or/and justification (4), (6) for the rejection of the other devices.
- Blanks in some of (2), (3), (4), (5) and (6).

So, we have three different degrees of assessing.

- "Naïve": wrong position & justification for choosing the right device.
- "Incomplete": right position for choosing the right device and wrong response on (2), (3), (4), (5) or (6), and
- "Full": full right response.

Figure 9 displays the analysis of student's macrostructure assessment process, and figure 10 displays an automated macrostructure question assessment example, in Prolog.

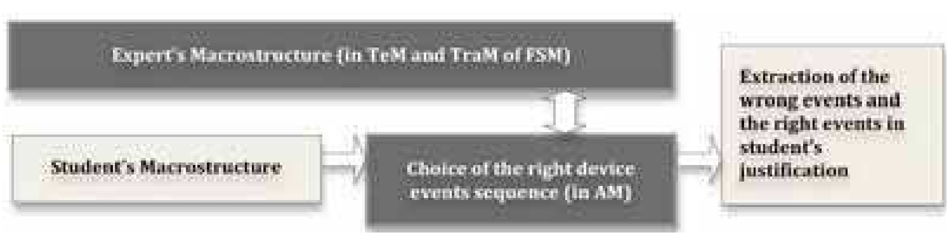



Fig. 9. Student's macrostructure assessment process

```
# 0.01 seconds to consult teleologia final.pl [c:\documents and settings\
| ?- inference_assessment(Position_Assessment,Justification_Assessment).
Give the right position:
|: router.
Give the position to be accessed:
|: repeater.
Position_Assessment = wrong ,
Justification_Assessment = naive

| ?- inference_assessment(Position_Assessment,Justification_Assessment).
Give the right position:
|: router.
Give the position to be assessed:
|: router.
Give the justification for the position:
|: convert_protocols.
|: exit.
Give the justification against the other devices:
|: repeater.
|: detect_protocols.
|: exit.
Position_Assessment = right ,
Justification_Assessment = incomplete ;

no

| ?- inference_assessment(Position_Assessment,Justification_Assessment).
Give the right position:
|: router.
Give the position to be accessed:
|: router.
Give the justification for the position:
|: convert_protocols.
|: exit.
Give the justification against the other devices:
|: repeater.
|: detect_protocols.
|: bridge.
|: convert_protocols.
|: switch.
|: compare_protocols.
|: exit.
Position_Assessment = right ,
Justification_Assessment = full ;
```

Fig. 10. Automated macrostructure question assessment

### 4.4 Enrichment Module (EnM)

The goal of the Enrichment Module is enriching the FSM knowledge base in three different ways: (i) inserting XML format lexical-semantic databases, obtained by semantic dictionaries, as Wordnet, (ii) inserting concept maps in XML format as well, provided by tools like CMapTools or Compass, and depicting an explicit representation of expert's knowledge structure (Novak, 1998) and (iii) inserting the content of expository texts referring to Computer Science domain. In the following section a semantic tool implementing the two first ways is presented.

## 5. Semandix – Constructing FSM & Implementing EnM

Semandix (*Seman*-tic *Dix*-ionary) is a semantic tool constructing the Functional System Module, meaning the knowledge base, and implementing a part of the Enrichment Module of the proposed system by using as a basis the cognitive Baudet-Denhière text comprehension model. It has been developed in Visual Basic .Net, under Microsoft SQL Server support and .Net Framework. Semandix gives also the capability of investigating concepts and relations appeared among them within a free text. Its ultimate goal is to assess automatically free-text responses by exploring alternative conceptions appearing within them always according to the text comprehension model of Denhière and Baudet.

### 5.1 Semandix Semantic Dictionary

Semantic dictionary of Semandix tool (figure 11) gives the possibility of searching a concept in the knowledge base of the system and presenting all relations referring to different structures of the cognitive model (relational, transformational, teleological) and the associated concepts with the searched concept.

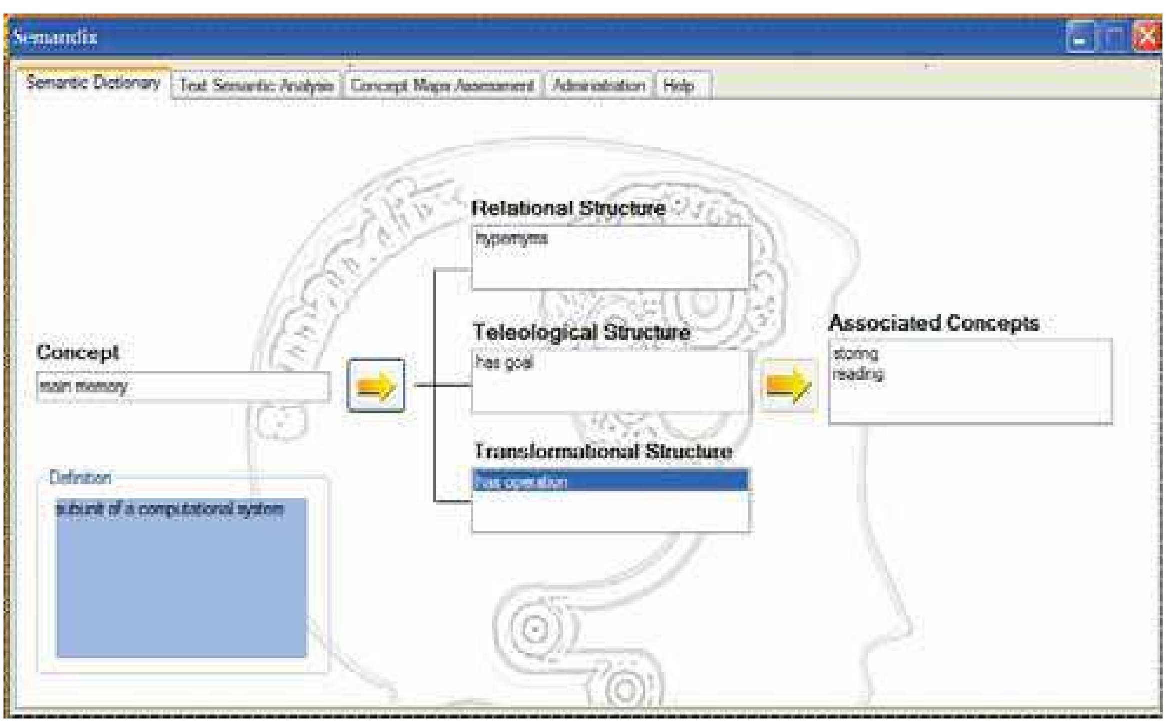


Fig. 11. Semantic Dictionary of Semandix

Selecting the transformational relation on the box of associated concepts, “storing” and “reading” appear, which are in fact two of the most important operations of the main memory of a computational system.

### 5.2 Semandix Knowledge Base Administration

The most important module of Semandix tool is the Administration tab (figure 12).
This module gives the administrator of the knowledge base the capability of:

- Adding individual concept and relation with other concept, identifying the type of model structure that relation refers to. In case the triad (concept, relation, concept) already exists the administrator is able to remove it or add a new definition for that concept (figure 12a). For the depicted examples we entered individual concepts in English.
- Enriching the knowledge base with content of concept maps and wordnets by adding XML format files extracted by CMapTools and Visdic, respectively (figure 12b). For the depicted examples we used a wordnet with concepts of “Computer Memory Hierarchy” domain in Greek, and Concept Maps expressing expert’s knowledge on the same subject.
- Enriching massively the system knowledge base with relations referring to every structure of the text comprehension model separately, in order for the tool to automatically categorize the incoming content to the right structure (figure 12c).
- Cleaning the whole knowledge base of the system (figure 12d).

For every new concept incoming to the knowledge base by the previous means, there is a parsing mechanism, which compares it with the existing concepts in the base, in order to eliminate wrong spelling or different case of the word expressing that concept.

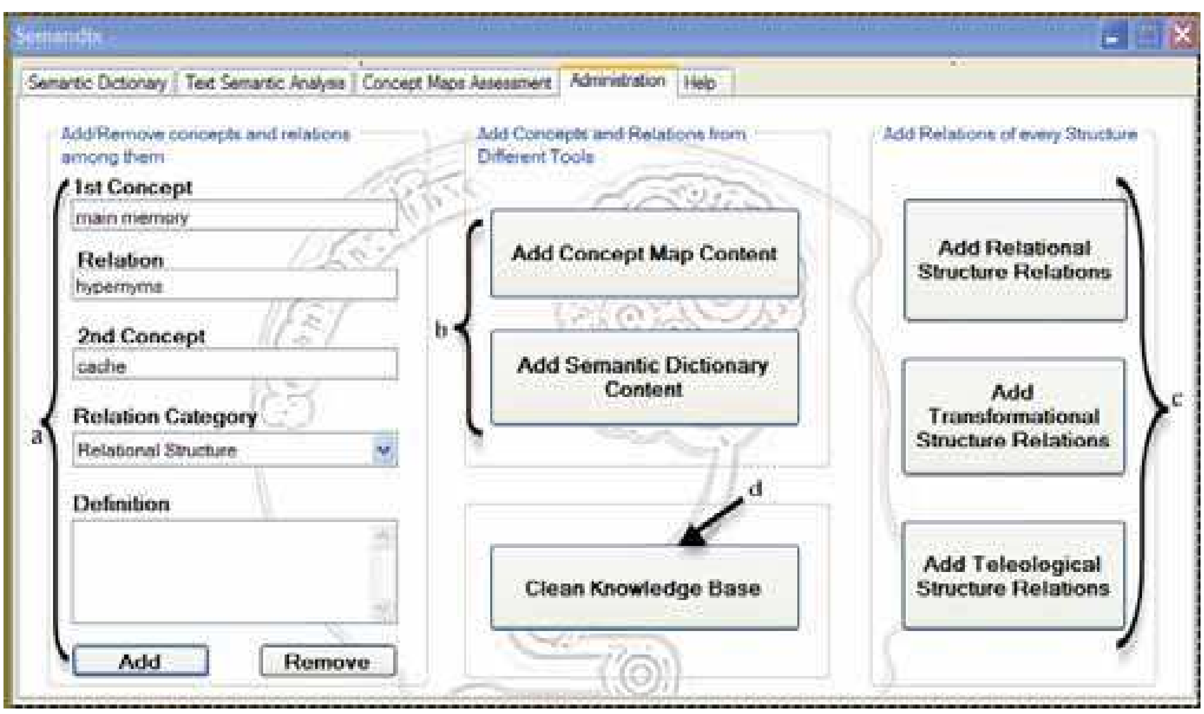


Fig. 12. Administration tab of Semandix

### 5.3 Semandix Text Semantic Analysis

Trying to implement the Assessment Module of the proposed system of the section 4, as a first step, Semandix gives the capability to a user of analyzing semantically the content of a short free-text response. This semantic analysis is constituted by the recognition of the concepts presented in the text and highlighting the relations among them. The Semandix enables the user to either type text or open a text file from his/her hard disk. After opening the text file the text will appear in the text field.
In figure 13 an example is presented in Greek. This Semantic Analysis could be combined with the assessment rules implemented in Prolog in section 4, in order to extract diagnosis of the alternative conceptions the user presents on the free-text response.

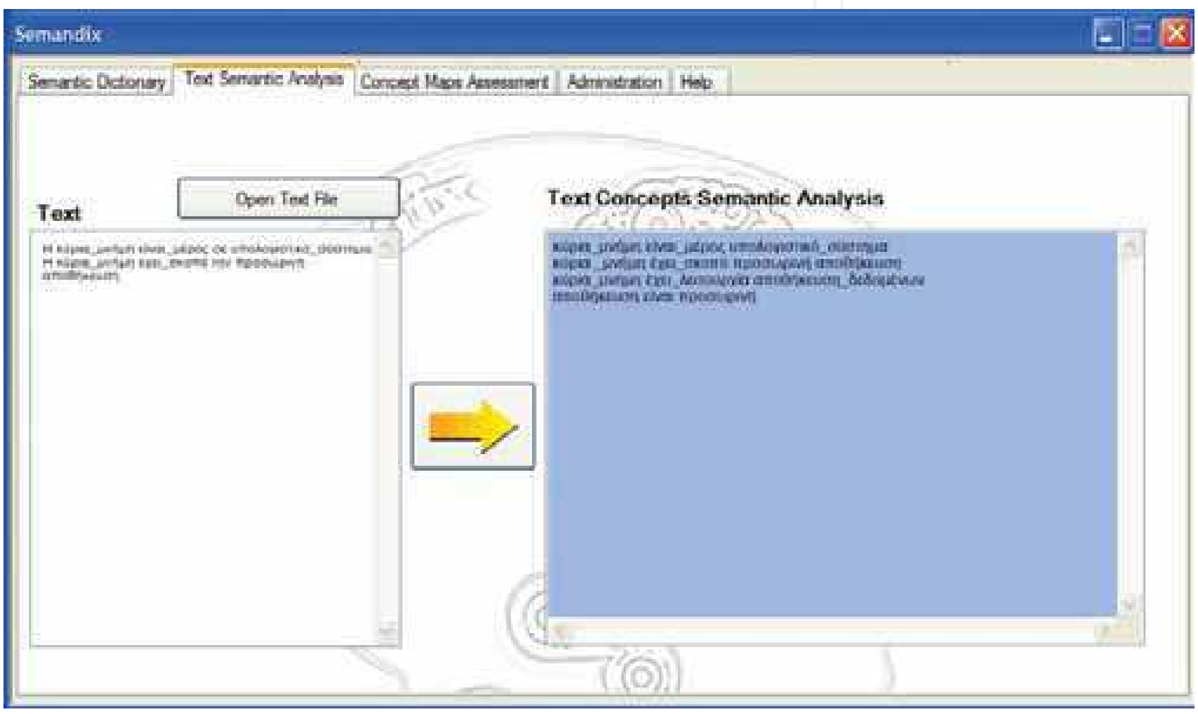


Fig. 13. Text Semantic Analysis tab of Semandix

### 5.4 Semandix Concept Map Assessment

Besides the text semantic analysis, Semandix concludes a module responsible for assessing propositions of a concept map created by a student (figure 14). The assessment process outputs the list of the propositions presented on the map. For each proposition there is a result "Right", whether the same proposition appears in the knowledge base, or "Wrong", whether there's not such a proposition in it. This assessment is superficial enough, but gives the opportunity of estimating quantitively the map correctness, without taking into account the alternative conceptions appeared on it.

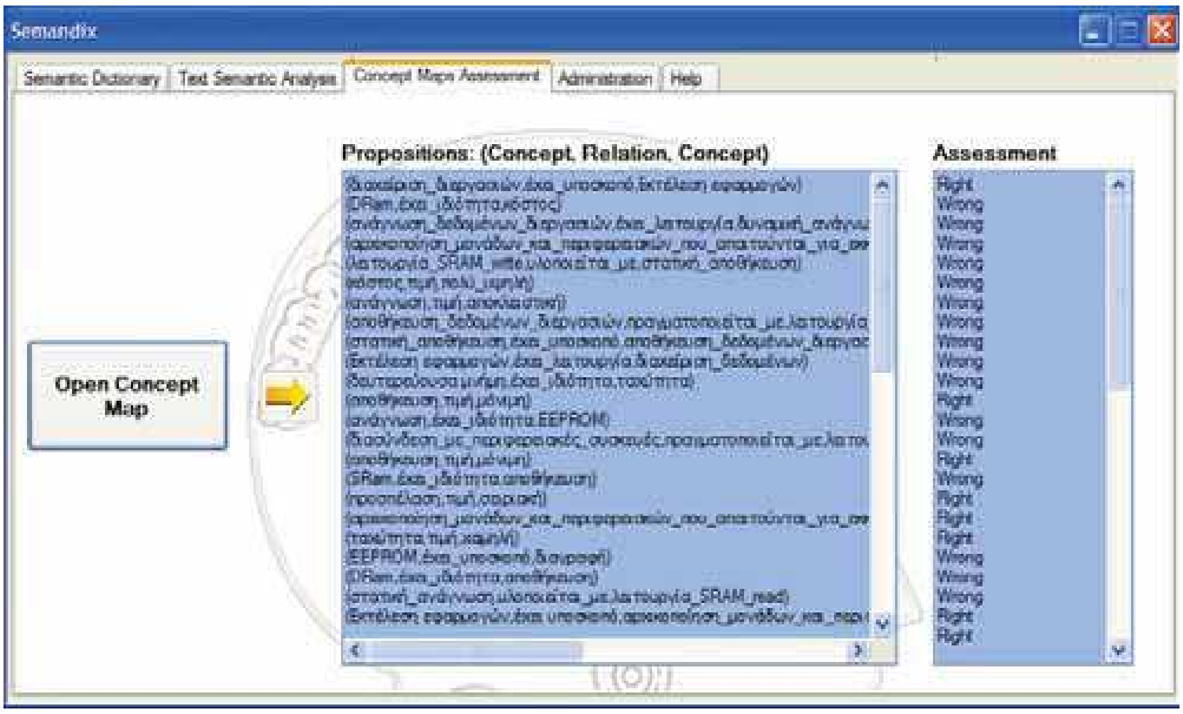



Fig. 14. Concept Maps Assessment tab of Semandix

## 6. Future Plans

This chapter has as a basic goal to introduce the design of a knowledge-based free-text assessment system and the efforts that have been made toward this direction by implementing basic modules of that system. It is obvious that, so far, all the implemented parts are not integrated into a whole working system; there are two implementations in different programming languages, Prolog and .Net Visual Basic, for Assessment, Functional System and Enrichment Module. So, our next step is combining the assessment rules created in Prolog with the Knowledge Base implemented in .Net Visual Basic under Microsoft SQL Server contribution. This fact leads to the need of connecting these two implementations.
Except for the combination of the above two implementations, it is necessary to

- implement the Normalization Module (NoM), in order for the system to accept as input free-text responses and normalize them, and
- elaborate Assessment Module, in order for it to diagnose alternative conceptions appeared, regarding the three substructures of the model, on the normalized responses with FSM knowledge base that includes the scientific conceptions.

For the first case, Natural Language Processing tools must be used, as

- Parsers, in order to process the free-text word by word,
- Taggers, in order to identify the syntactic role of every word in a sentence, and
- Grammars, in order to identify the grammatical role of every word in a sentence.

For the second case, there must be enrichment of Semandix Knowledge Base with content expressing the alternative conceptions that readers have during reading expository texts of the domain of Computer Science. These concepts could be in propositional form through concept mapping assessment procedure or coming from responses on open-ended questions answered by such readers, meaning that this system could “learn” during its use.

## 7. References

Baudet, S. & Denhière, G. (1992). Lecture, comprehension de texte et science cognitive. Presses Universitaires de France, Paris.

Blitsas, P.; Papadopoulos, G. & Grigoriadou, M. (2009). How Concept Mapping Can Support Technical Systems Understanding Based on Denhière-Baudet Text Comprehension Model, Proceedings of the 9th IEEE International Conference on Advanced Learning Technologies (ICALT 2009), Riga, Latvia, 14-18 July 2009 (under publication).

Blitsas, P. & Grigoriadou, M. (2008). Towards A Knowledge-Based Free-Text Response Assessment System, Proceedings of the IADIS International Conference in Cognition and Exploratory Learning in Digital Age (CELDA 2008), Freiburg, Germany, October 13–15, 2008, pp. 37-44.

Brookshear, G. (2006). Computer Science: An Overview, Pearson Addison Wesley, Ninth Edition.

Graesser, A. & Tipping, P. (1999). Understanding texts, In: Bechtel, W., Graham, G. (eds.) A Companion to Cognitive Science, Malden MA: Blackwell, chapter 24.

Gruber, T. (1993). Toward Principles for the Design of Ontologies Used for Knowledge Sharing, Technical Report KSL 93-04, Stanford University, Knowledge Systems Laboratory, Revision.

Kintsch, W. (2001). Predication. Cognitive Science, Vol. 25, pp 173-202.

Kintsch, W. (1992). A cognitive architecture for comprehension. In: Pick, H.L., van den Broek, P., Knill, D.C. (eds.) The study of cognition: Conceptual and methodological issues Washington, DC, American Psychological Association, pp. 143-164.

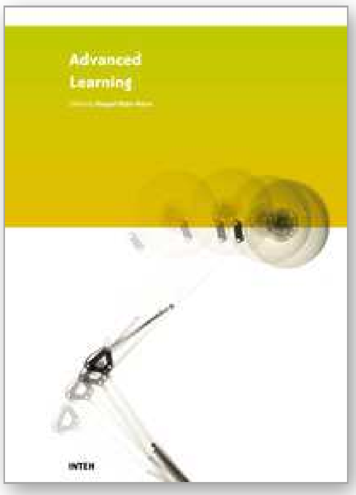
Landauer, T. & Dumais, S. (1997). A solution to Plato's problem: the Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. Psychological Review, Vol. 104, No. 2, pp 211-240.

Lemaire, B.; Denhière, G. et al (2006). A computational model for simulating text comprehension, Behavior Research methods, Vol. 38 No. 4, pp 628-637.

Novak, J. & Musonda, D. (1991). A Twelve-year longitudinal study of Science Concept Learning. American Educational Research Journal, 28(1), 117-153.

Novak, J. & Gowin, B. (1984). Learning How to Learn. New York: Cambridge University Press.

Rinaldi, F.; Dowdall, J. et al (2002). Towards Response Extraction: An Application to Technical Domains. In: F. van Harmelen (eds.), Proceeding of the 15th European Conference on Artificial Intelligence, Amsterdam IOS Press, pp. 460-464.




**Advanced Learning**

Edited by Raquel Hijn-Neira

ISBN 978-953-307-010-0
Hard cover, 444 pages
**Publisher** InTech
**Published online** 01, October, 2009
**Published in print edition** October, 2009

The education industry has obviously been influenced by the Internet revolution. Teaching and learning methods have changed significantly since the coming of the Web and it is very likely they will keep evolving many years to come thanks to it. A good example of this changing reality is the spectacular development of e-Learning. In a more particular way, the Web 2.0 has offered to the teaching industry a set of tools and practices that are modifying the learning systems and knowledge transmission methods. Teachers and students can use these tools in a variety of ways aimed to the general purpose of promoting collaborative work. The editor would like to thank the authors, who have committed so much effort to the publication of this work. She is sure that this volume will certainly be of great help for students, teachers and researchers. This was, at least, the main aim of the authors.



**InTech Europe**
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

**InTech China**
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821