SEMANTICS ANALYSIS AND INSTRUCTIONAL DESIGN

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Abstract

The macro design phase of learning paths starts with the content analysis. Unfortunately this activity involves some weak points related to the process management and the loss of information risk. Therefore lately concept maps have become a useful tool in order to tackle this issue: as formal representation of knowledge system of courses they’re also an output of the content analysis. On the other hand our experience shows how a concept map is often a closed tool exclusively used to make knowledge systems more explicit. Rarely, in fact, the map is an aid to supply contents or assess learning activities.

In the last years a new content analysis approach has been developed: the study of a concept starting from its main categorizations in order to identify its “basic structure”.

In such context, the formal representation of contents in a semantic way can’t be just defined by concept maps but needs more complex and sophisticated tools, the “ontologies”.

The present paper develops the hypothesis that OWL ontologies can be used in the instructional design process, as content analysis and formal representation tools. In particular it wants to show how and at which point ontologies can be alternative or complementary to concept maps.

According to our hypothesis, ontologies could support the macro design phase by solving some conceptual gaps, in particular the transition from the Formal representation of contents of a concept map to the definition of the learning objectives tree hierarchic structure. Moreover they can be used in the micro design and assessment phase and also can be useful to design a new course. That will imply new ways to define the Semantic Density, a fundamental parameter to identify the lesson structure and path and to define learning time. With a dynamic and linear vision of the course knowledge domain, they could enable the definition of learning objectives structures as flowcharts.

In this sense, we present a research method articulated in six activities:

1. Identification of the content to analyse.
2. Definition of concept map (with Cmap Tools).
3. Definition of ontology (with Altova Semanticworks).
4. Comparison between map and ontology to identify differences, similarities, advantages and disadvantages.
5. Implementation of a theoretical model to define a content semantic density (related to a learning objective) depending on its ontological analysis (hierarchies and categorizations check).
6. Identification of a possible integration of ontologies in the learning design standardized process: the new model of content analysis.

Ultimately, in order to concretely evaluate the opportunities that ontologies entail, we defined a map and an ontology from the same content (a math concept from Wikipedia). Then we compared the tools in three ways: (a) methodological, by underlining the relative semantic analysis functions and possibilities; (b) applicative, by defining how they can be useful in all the process phases and in which specific domains (for instance content analysis, semi-structured tests measurement, customized learning paths); (c) managerial, by defining how these tools can be part of the design process.

The research output was a guideline to define ontologies with didactic objectives, a document being part of a more extended methodology to manage any sort of content.

Keywords: Ontology, content analysis, semantics analysis, formal representation, concept map, semantic density, objectives tree
1 REFERENCE SCENARIO

The macro design phase of learning paths starts with the content analysis. In the past we have already pointed out that this kind of activity involves some weak points related to the process management and the loss of information risk [1]. In the last years concept maps have become useful tools in order to tackle this issue: as formal representation of knowledge system of courses they are also an output of the content analysis [2]. In fact they allow representing complex knowledge areas through the definition of concepts and relations between them. They are also an easy tool that can be used both in the design phase by instructional designers and in the revision phase by content specialists and clients [3]. Recently, our research team has also developed a new model of learning object based on dynamic concept maps [4] that help the student organization of the course and allow a high degree of optimization of learning time. Nevertheless, our experience shows how a concept map is often a closed tool exclusively used to make knowledge systems more explicit. Unlike learning objectives trees, the map is not frequently used to define parameters, structure and learning path features. Rarely it becomes an aid to supply contents or assess learning activities.

Moreover, we experimented that concept maps are an unsound basis for managing the content of a course. In fact, starting from the same content source, many instructional designers could create very different concept maps because there is not a reliable method to represent an information system with this tool. Novak and others scholars [2] provided some guidelines about the design process of a concept map, but these specifications do not guarantee a standardization of the output. This clearly led to a proliferation of sometimes very divergent representations of the same knowledge system, and does not allow effective monitoring of the instructional design process. Therefore, these limits show a substantial weakness of the concept maps - at least in their current version - in the activity of analysis and formal organization of the contents of a course.

Looking for more reliable methods for the representation of knowledge systems, in the last years, especially in the academic field, a new content analysis approach has been developed: the study of a concept starting from its main categorizations in order to identify its “basic structure”. In such context, the formal representation of contents in a semantic way cannot be just defined by concept maps but needs more complex and sophisticated tools: the “ontologies”. An “ontology” is not only a theoretical and philosophical practice but can also generate some concrete applications. For instance the Semantic Web, which is meant to allow users doing more precise and effective researches on the Internet. Through applications (search engines based on intelligent agents) the Semantic Web can acknowledge and assign the right meaning of a text depending on the research context. The main ontologies language codes, such as RDF or OWL, allow codifying knowledge through a formal representation of concepts, terms and relationships of a specific domain to make it understandable to agents searching that information [5]. Unlike concept maps, developing ontologies entails some advantages and helps: to share the understanding of information structure among people or artificial agents; to reuse a knowledge domain; to make the hypothesis about the domain more explicit; to analyze the knowledge domain. Then, in light of these strengths, adopting ontologies as knowledge domains in the content analysis phase could open new scenarios:

1. The sharing of knowledge between courses about close topics. If these courses shared the same ontology for the used terms, an artificial agent could get a higher amount of information and aggregate it. The agent could be used to answer users specific questions (virtual agent tutor) or to evaluate students’ knowledge by means of a semantic analysis of the answers they have provided in an open text box.

2. The molecular structure of the knowledge representation. If an ontology correctly describes a specific concept, for instance a law, such knowledge domain could be reused in a new course. Furthermore, for an extended ontology, more ontologies could be integrated.

3. Explicit domain hypothesis makes the find or change of definitions easy, if required.

4. Analyzing a knowledge domain is possible if a declarative specification is available. Formal analysis of terms is very important when one aims at reusing and extending existing ontologies.

2 RESEARCH GOAL

The present paper develops the hypothesis that OWL ontologies can be integrated in the instructional design process, as important tools for content analysis and formal representation. In particular it wants
to show if and how ontologies could be alternative or complementary to concept maps. In theory, ontologies are "living" tools. They can grow with the contribution of different designers in different courses and at different moments. They can be used in the micro design, supply and assessment phase and also be useful for a new course design. Ontologies are strongly structured entities, therefore designers cannot subjectively interpret them. As they are standardized, they can integrate computerized systems as well. In addition they could support the macro design phase by solving some conceptual gaps, in particular the transition from the formal representation of contents of a concept map and the definition of the learning objectives tree hierarchic structure.

In the semantic analysis of content, ontologies could also enable the identification (and definition) of the categorization levels in a rigorous and objective way. That will imply new ways to define the Semantic Density, a fundamental parameter to identify the lesson structure and path and define learning time. With a dynamic and linear vision of the course knowledge domain, they could enable the definition of learning objectives structures as flowcharts. Unfortunately, as we shall see, the use of semantic models in instructional design has some weaknesses, including, of course, the increase of the time needed for the design and the necessity for designers to be trained on the use of the software for the creation of ontologies. For this reason it is necessary to carefully check the opportunities and the scope of these tools in the process of analysis and representation of content. In this sense, starting from the same information system (i.e. the contents of the course), we will try to compare the output provided, respectively, through the use of concept maps and the adoption of ontologies, and then decide how to handle these two methods to improve the design process.

3 METHODOLOGY AND WORK PHASES
From an operational point of view, in order to achieve our goal, the research project is divided into six phases:

1. Identification of the content to analyse.
2. Definition of concept map (with Cmap Tools).
3. Definition of ontology (with Altova Semanticworks).
4. Comparison between map and ontology to identify differences and similarities.
5. Implementation of a theoretical model to define a content semantic density (related to a learning objective) depending on its ontological analysis (hierarchies and categorizations check).
6. Identification of a possible integration of ontologies in the learning design standardized process: the new model of content analysis.

The following paragraphs describe each phase.

3.1 Identification of the content to analyse
The starting phase of the process is focused on the identification of a specific content for the analysis and the subsequent creation of the map. Because of the goal and the characteristics of this research, we needed to find an extremely structured, simple and possibly unchangeable content, in order to avoid any interpretation problems during the instructional designers’ analysis. We chose a mathematical concept: the term “Line (geometry)”, as it is described in Wikipedia (http://en.wikipedia.org/wiki/Straight_line), associated to the term “Linear equation” (http://en.wikipedia.org/wiki/Linear_equation).

3.2 Definition of concept map
3.2.1 Map exportation
The following phase was focused on the creation of a concept map on the selected content. In order to verify that the concept map is an objective representation of the knowledge domain, we asked four instructional designers to make a concept map, using Cmap Tools software. The four maps were afterwards exported as “text proposition” mode. The result was a list of propositions for each of them, organized as follows:

   Concept A (subject) – Relationship (correlation element) – Concept B (object)
3.2.2 Data normalization

The maps exportation in list of propositions pointed out that there was an extremely high level of variability about elements, relations and structures of the four maps: each instructional designer interpreted the contents in a personal way. This variability did not allow an immediate comparison. For this reason it was implemented a normalization activity on nodes and relations, that means a definition of a set of criteria.

We created a conversion table of subject and object, through the cataloguing of each term with a specific code. Then, similar terms and synonyms (for example: “line, unique line, the line, straight line”) have been included in a short list, that is the real conversion table. The same operation has been applied to subjects and objects, counted all together as “concept”. It has been defined a set of substitution rules about characteristics and elements linked to a noun, as articles, conjunctions, singular/plural, adjectives. In this phase the main effort was to bring back all the different synonyms and shades of meaning to the same class, in order to obtain a narrowed universe of objects.

As for concepts, we created a conversion table of connections, that represents the elements that instructional designers used to link two different concepts (subject and object). These relations were basically represented by: verbs (in all forms and declinations), adverbs, conjunctions, clauses, pronouns. The normalization process took part in two phases:

1. Identification of similar elements that occur in the maps. It means all declination of a specific verb (also including modals verbs) and all declinations of synonymous of a specific verb (for example: “is, to represent, that is, which were, represents, could be”); or conjunctions with identical meaning (for example: “as, like”).

2. Analysis of properties of relations in order to assign each element (or group of elements, after the activity described at point 1.) to a specific logic category that allows to identify which type of relation joins subject and object:

<table>
<thead>
<tr>
<th>Logic relation</th>
<th>Standard term</th>
<th>Explanation of behaviour and objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS</td>
<td>is</td>
<td>He/she is able to define a concept</td>
</tr>
<tr>
<td>IN &lt;--</td>
<td>includes</td>
<td>He/she is able to define the relationship between two distinct elements</td>
</tr>
<tr>
<td>IN --&gt;</td>
<td>is included in</td>
<td>He/she is able to define the relationship between two distinct elements</td>
</tr>
<tr>
<td>not IN &lt;--</td>
<td>is not included in</td>
<td>He/she is able to define the relationship between two distinct elements</td>
</tr>
<tr>
<td>OR</td>
<td>or</td>
<td>He/she is able to define the relationship between two distinct elements</td>
</tr>
<tr>
<td>AND</td>
<td>is connected to</td>
<td>He/she is able to define the relationship between two distinct elements</td>
</tr>
<tr>
<td>IF THEN --&gt;</td>
<td>implies</td>
<td>He/she is able to define the conditional connection between two elements</td>
</tr>
<tr>
<td>IF THEN &lt;--</td>
<td>is derived from</td>
<td>He/she is able to define the conditional connection between two elements</td>
</tr>
</tbody>
</table>

Table 1: Properties of relationships

3.2.3 Creation and comparison of standardized concept maps

The identification of clusters for nodes and relations allowed us to eliminate the maps variability: all the terms used in the four maps were substituted with a unique and standard term that represents the entire category. In this way, we derived four comparable concept maps. At this point we decided to compare the four maps on the basis of four key indicators:

1. The amount of concepts in each map: thanks to this variable we can estimate the degree of coherence of the concept map simply in relation to the number of nodes that describe the information system.
2. The different distribution of key concepts: we can highlight the different kinds of interpretation of the conceptual framework by the four instructional designers through the emphasis that each of them decided to put on some key issues.

3. The number of relations between the nodes of the map: this variable allows us to compare the different degree of “structural organization” of each map, in other terms, what we call level of “semantic density”.

4. The difference in frequency of the fundamental relationships between the nodes of each map: this factor allows us to estimate the different levels of complexity attributed to connections between concepts by the four designers.

What were the results of this comparative analysis?

As concerns the first indicator, the total number of concepts, the graph immediately displays some gaps among the four representations, with a number of nodes ranging from 29 to 44. This means that, even if they refer to the same source of information, the maps show heterogeneity in terms of thoroughness and completeness. The lack of homogeneity is even more relevant in the chart on the different distribution of the 10 key concepts within the four maps.
It is clear that, beyond a few common macroscopic features (the obvious centrality of the concepts of "line" and "linear equation") the weights assigned to the different key concepts vary in a considerable manner. And nothing changes if we analyze the number of relations in each map, where the oscillation between the minimum and the maximum value highlights the different perspectives of the four designers in the interpretation of the different logical connections between concepts.

**Figure 3:** Total number of relations in the four different maps

Finally, the heterogeneity between the maps reached significant values in the case of the different distribution of the fundamental logical relations.

**Figure 4:** Eight basic relations in the four different maps

The graph clearly shows the substantial difference of perspective and interpretation of the meaning of the different logical connections between concepts and, in general, the level of complexity of information. In fact, if you exclude the obvious convergence of the four designers on the fundamental relationship of identity ("is"), these results could make us think the four designers analysed four different texts on the concept of “line”. But we know this is not true, because the reference source was the same and the four designers belong to the same team and have been working together for several years.

### 3.2.4 Results of comparison

What are the causes of such heterogeneous results? Basically, we can identify at least six factors that influence a designer during the activities of content analysis and elaboration of the concept map:

1. **Previous knowledge on the topic.**
2. Degree of "confidence" with the software for building concept maps.
3. Professional experience gained in relation to the method of creation of concept maps.
4. Type of curriculum, i.e. scientific or humanistic.
5. "Forma mentis" of the designer, according to Gardner's taxonomy.
6. Disposition to the learning objectives and to the structure of the course.

All these variables influence the designer when he/she selects the key concepts and defines the different connections, the logical structure of the visual map, the weight of the various logical connectives and the density of relations between nodes.

3.3 Definition of ontology

Starting from these considerations, it is clear that a design process cannot be based on such shaky foundations. It becomes therefore necessary to evolve through the integration of the method with a more stringent set of criteria and techniques of content analysis that are less sensitive to the specific external observer. That's why we tried to manage the same content using a knowledge representation system that is able to represent information about categories of objects pertaining to a specific domain and their interdependencies. The adoption of a Web Ontology answered the need for a system with a rigid and consistent set of rules for the analysis of knowledge domain.

The ontology has been created in OWL Full language, on the same concept maps contents ("Straight line"), using Altova Semantic Works software. The main activities of workflow of the ontology design are:

- Creation of the new classes.
- Creation of the class hierarchy.
- Creation of the properties.
- Check of the relationships between properties and classes.
- Creation of instances.
- Check of the relationships between instances and classes.

Figure 5: Section of "Straight Line" Ontology realized with Altova Semantic Works

The creation of OWL Ontology is an intensive process, and requires many efforts and time. In this case, we adopted a manual ontology construction approach (instead of an automatic creation) in order to test and to try out the potentialities and difficulties that an instructional designer has to face in order to generate a description of the knowledge domain. At first, we detected the key words in the provided contents and created the respective class. Then we arranged the class hierarchy, sifting out which classes were subclasses of other ones. We created pertinent items and for each of them we defined relationships, as for example if a class represent the "union" or the "intersection" of other two. Furthermore, we analyzed hyponym-hypernym relations, in order to define which elements were
instances of a specific class. We handled the common problem when you build an ontology, that is how to simplify assumptions, without losing much information.

3.4 Comparison between concept map and ontology approach

3.4.1 Language classification

The creation of concept maps and Web ontologies requires the classification of the analyzed subject. In this phase, the instructional designer carries out a linguistic interpretation in order to analyze, understand, explicit and catalogue terms and relationships that link different objects. It is a meta-process: the designer reads and renders a document or large text body, and then builds an ontology understandable by natural language processing applications or by other AI applications. In a nutshell, a part of macro design process consists in distinguishing elements within a certain knowledge domain and in the subsequent specification of meaningful connections among objects. The goal is not the creation of a perfect taxonomy of the known universe, but rather a representation that is close to reality and able to explain syntactic structure of text.

3.4.2 Characteristics comparison between Concept Maps and Web Ontologies

At this point, we benchmarked both tested methods of knowledge conceptualization. We analyzed differences and similarities of concept maps and ontologies, referring to the use we have done of CMap Tools and Altova Semantic Works. Let’s start from the comparison of peculiarities between the different approaches:

<table>
<thead>
<tr>
<th>Concept map</th>
<th>Ontology</th>
</tr>
</thead>
<tbody>
<tr>
<td>It answers to a specific question about a topic</td>
<td>It gives main information about a knowledge domain</td>
</tr>
<tr>
<td>It is auto-consistent</td>
<td>It could be dynamically joined with pre-existing ontologies</td>
</tr>
<tr>
<td>It is context oriented</td>
<td>It is general/universal</td>
</tr>
<tr>
<td>It is easily readable in the graphic format. CMap Tools allows the map exportation in XTM format or as Text propositions</td>
<td>It is language machine-processable (containing metadata information), but less understandable by human beings without technical skills</td>
</tr>
<tr>
<td>The set of design rules are simple and flexible depending on designer’s interpretation</td>
<td>The set of design rules is strictly structured, according to Web Ontologies Language</td>
</tr>
</tbody>
</table>

Table 2: Comparison between concept maps and ontologies characteristics

On the other hand, several analogies between concept maps and ontologies could be listed:

- answer to main questions about topic;
- set up of a knowledge domain, starting from identification of knowledge atoms;
- organization of a semantic structure based on concepts linked by verbs;
- organization of concepts on hierarchical levels;
- setting up of interrelations among different objects (called “linking words” in concept maps, “properties” in ontologies);
- identification of a closed group of key concepts, that must be arranged from general to specific ones;
- open structure allowing subsequent changes on semantic relations, as far as the introduction of new elements.

3.5 Implementation of a theoretical model to define a content semantic density depending on its ontological analysis

Before proceeding with the detailed presentation of the new method of content analysis it is necessary to focus on some theoretical issues, with a special focus on "semantic density." The design of a
learning path implies the analysis of the knowledge domain of the course, from both a qualitative point of view (identification of complexity level of the mental model) and a quantitative one (identification of the number of “terms” that constitute the minimum vocabulary of the mental model). Thanks to the analysis of these two parameters the designer can define the structure of the course according to prerequisites: he/she can identify at first the simple concepts and then the complex ones, and then distribute the quantity of new terms among the different lessons in a balanced way. The ways in which you can mix the amount of information during the learning time and type of dosage levels of complexity largely determine the degree of effectiveness of a training plan.

However, whereas for the qualitative dimension, you can refer to a set of taxonomies and rules that are already established in the scientific community, for the quantitative dimension the definition of the “Semantic density” is based on common sense and experience of instructional designers. This is a real point of weakness and depends essentially on three factors:

- the concept of "semantic density" is inherently unclear because it is related with philosophical, epistemological and psychological evocations;
- there is no scientific literature on the subject to explicitly clarify the theoretical significance of this variable. The only similar concept is the "cognitive load", which is not measurable;
- there are very few cases where, beyond the simple statements, this quantitative dimension of information systems has been effectively applied and monitored in the analysis of the contents of a course.

The introduction of content semantic analysis techniques allows us to overcome this impasse and create a more stringent definition of "semantic density", defined as a variable describing the plot of interconnections between the nodes that make up a concept map. More operationally, you can define the “semantic density” of an information system as the value that directly expresses the total number of relationships of the concept map "normalized" to represent it. This definition allows us to disambiguate the concept under examination and helps to clarify the mechanism we have adopted so far for the calculation of the learning time [6].

### 3.6 Identification of a possible integration of ontologies in the learning design

**Standardized process: the new model of content analysis**

The method of semantic analysis of content that we propose starts from the premise that the concept map is still an essential basis for identifying the elements that are part of an ontology on the same subject. However the content analysis will no longer have the concept map as a single output, but it will be a joined analysis of the concepts and relationships of the domain of knowledge through the construction of its ontological representation in OWL. In this regard, in the macro design process the two types of output could be integrated as well: 1) the concept map for the identification of basic elements; 2) the ontology for the identification of relations among elements (properties).

Looking at the process, the methodology provides a comparison between concept map and ontology, passing from one to the other until an appropriate level of content “is covered”.

![Figure 6: Process of outputs in macro design activity](image)

What is the goal of this comparison? The design model adopted provided for a fragmentation of the concept map in clusters that corresponded to specific learning objectives. Learning objectives were afterwards represented by means of a diagram. The transition from concept map to learning objectives resulted quite forced. Thanks to the integration of these two instruments in the content analysis activity, the transition from the binomium “concept map-ontology” to the diagram of learning objectives will allow to move in a more rigorous way from the identification of single objectives to the identification of clusters of objectives. These clusters represent the minimum core of behaviors that enable assessment. To reach this goal, the methodology we propose is constituted by the following phases:
Starting from these considerations, ontology can be considered the bridge between concept map and diagram of learning objectives, since it requests both semantic analysis of contents and hierarchization of contents in a stable and precise structure.

In this specific case, in fact, the normalization of concept maps relationships previously described in paragraph 3.2 allowed the creation of an ontology on “Straight line”.

It is important to consider that the design of ontology implies the description of classes and instances, the identification of logic relationships (properties) between objects, the arranging of hierarchic level. These operations are not always intuitive, and require time in order to detect all the logical connections among elements. Moreover, an OWL ontology can generally specify if a property is transitive, symmetric, functional, or is the inverse of another property.

Therefore, the heavy phase of information extraction has been eased in this case by a “normalization” data process created on concept maps. In fact, the standardized list of object and relationships has been functional to the arrangement of classes and properties. In particular, the short list of connection selected for the development of standardized concept maps have been “translated” in Web Ontology’s logical relation as follows:

- Is \( \rightarrow \) “subclass of”;

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**Figure 7: Phases for creation of concept map, ontology and objectives diagram**

**Figure 8: Same part of “Straight line” content represented with Ontology and with Concept Map**
Includes $\rightarrow$ “subclass of”;
Is included in $\rightarrow$ “subclass of”;
Is not included in $\rightarrow$ “disjoint with”;
Or $\rightarrow$ “disjoint with”;
Is connected to $\rightarrow$ “intersection of”;
Implies $\rightarrow$ “subclass of”;
Is derived from $\rightarrow$ “complement of”.

Logically, this is a first draft of logic relation translation, not necessarily exhaustive. According to the connections of the knowledge domain, the conversion list could be enriched. Even if a basic version of Web Ontology has been created, it seemed clear that the design of formal representation of knowledge is a complex process requiring technical skills.

Moreover, the data normalization of concept maps permitted the definition of a new set of rules about concept maps design: the rules of substitution of nouns and relationships, in fact, constitute a kind of guidelines for the creation of concepts maps with the same “language” of design. These rules could also represents a useful guide and support tool for new designers who have to interpret a new content for the first time, but also for designers with experience, who can optimize the activity of creation of concept maps. The introduction of these standardization rules of concept maps produces at least two positive effects in the economy of design process:

- It creates a strong link among the creation of the concept map and the ontology and identification of course structure, until now correlated only to analysis of tree and flowchart of learning objectives;
- It permits to reach univocity for all outputs of design process (in this case of concept maps, that presented strong differences until now, because of the different designers). This fact has important management implications, because it guarantees that the definition of structure of concepts and meanings of knowledge domain of the course (and consequently the identification of semantic density and of course structure and prediction of learning time) do not suffer modifications if the designer who works on the project must be replaced or helped.

It is finally clear that, after the creation of concept map with standardization rules and its correlated ontology OWL, the designer will have all the information to prosecute in the definition of objectives flowchart through:

- identification of clusters on which focus assessment;
- identification of propaedeutic rules;
- identification of activity flow.

4 THEORETICAL PROPOSITION

Our teamwork experimented this methodology with ID4C model, a design model integrated in a reference scientific theory [3]. In the macro design phase the content analysis is aimed to define a concept map to allow the designer analyzing contents and defining concept relations in the map. All course texts and learning aids are schematized. The definition of the concept map allows analyzing a period, a text or other kinds of information and synthesizing the more significant among them by identifying moreover their connections in the map. Then, in the micro design phase, the cognitive process of instructional designer is the opposite: starting from the map schematization reconverted in the learning objectives tree, the final step is the text redefinition, in a fluid and extended information processing [7].

In this research we add an intermediate step: going from a functional description of mental models [8] and behaviors to a more extended and structured semantic analysis in the micro design phase. Adopting semantic analysis and formal representation of contents in the macro design phase – to replace or integrate many kinds of courses and training aids – is useful, for instance, to assess a course with semi-structured tests. Defining an ontology as a database of information and connections understandable by an intelligent system allows assessing the knowledge a learner can express through a written text that freely reproduces those connections. It could also be possible to reverse the
process by first defining the ontology and then letting the software creating the concept map. The semantic analysis advantage is the facilitation in designing homogenous contents representation tools.

To sum up:
- content analysis and formal representation are fundamental: until now, in our instructional design model, we used concept maps;
- proposal evolution: executing a semantic analysis, more exhaustive, with the software Semanticworks in order to define ontologies;
- goal: defining a macro design step for the semantic analysis, alternative or complementary to concept maps content analysis.

5 CONCRETE APPLICATION (PROTOTYPE)

In order to concretely evaluate the opportunities ontologies entail, we defined from the same content (a math concept from Wikipedia) a map and an ontology. Then we compared the tools in three ways:
- methodological, by underlining the relative semantic analysis functions and possibilities;
- applicative, by defining how they can be useful in all the process phases and in which specific domains (for instance content analysis, semi-structured tests measurement, customized learning paths);
- managerial, by defining how these tools can be part of the design process.

The experimentation on a sample of learning designers to compare the definition of a concept map (content analysis) and an ontology (semantic analysis) allowed analyzing the strengths of both methods as output of the learning design analysis phase. The research output was a guideline to define ontologies with didactic objectives, a document being part of a more extended methodology to “handle” any sort of content. In this sense, a stable methodology to define ontologies in order to acquire and standardize various knowledge sources and information allows hypothesizing some future applications in:
- the archives analysis, like Enciclopedia Treccani or Encyclopaedia Britannica;
- the analysis of private companies knowledge databases collecting different kinds of documentation;
- the definition of assessment systems for non-structured tests.

REFERENCES


