

# Metaphors in Learning Environments: Towards a Taxonomy

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## Abstract

*Metaphors are becoming more and more used in computer-based learning environments, but it is often difficult to identify what type of metaphor is involved. We propose to extend the categories which have been defined in human-computer interaction field. Four categories are distinguished according to which part of the system is concerned: design metaphors, interface metaphors, scenario metaphors and content metaphors. We define the categories and we give examples for each one.*

## 1. Introduction

As well as in other disciplines like linguistic, philosophy and psychology, analogies and metaphors seem to be more and more studied and used in the education field. Indeed, reasoning by analogy is now considered as a main thinking mode, analogy is acknowledged as an important instructional strategy, and moreover analogies have an increased importance in actual society because of numerous systems of reference shared by a lot of people (like a scene in a movie or advertising referring to a scene in another movie).

Many scientific research has been done on analogy and metaphor. The importance of metaphors as models has been promoted by Black [1]. The cognitive process underlying analogy has been studied by psychologists like Gentner [11] and Holyoack [12]. The use, potential benefits and potential problems of analogies and metaphors have also been studied in education, for example reviewed by Duit [10] and in Ortony [22]. Finally Lakoff [15] has stressed the importance of metaphors in every-day life.

A first problem when studying analogy and metaphor is to face with the variety of definitions for each term, depending on the author and on the discipline. We will not argue on this topic in this paper: we choose here the word metaphor, because it is probably more used in the computer-based learning environments community. We consider that metaphor is resemblance between things belonging to semantically separate knowledge domains. The basic principle of metaphors for learning is to base the new knowledge to be acquired in a domain (target domain) on a previous known domain (source domain).

Another problem when studying metaphors within computer-based learning environments is to identify what are exactly the types of metaphors taken into account. Indeed, what are the commonalities between a small metaphoric icon representing a function, like the scissors for the "cut" function existing in almost all software, and a whole screen metaphoric scene of a multimedia learning environment ? Apart from visual differences, the purposes of those metaphors are obviously not the same. This is the question we address in this paper: we try to identify the categories of metaphors in a computer-based learning environment.

## 2. Categories of metaphors in learning environments

In the field of human-computer interaction (HCI), two main categories of metaphors can be distinguished. *Interface metaphors* have been studied for a long time as in Carroll [5]. *Design metaphors* are more recently studied, like in the work of Madsen [17]. Those metaphors can be present in any computer-based environment, including learning environments. Moreover, we think those categories are not detailed enough to be suitable for learning environments and that two new

categories should be defined: *scenario metaphors* and *content metaphors*.

So we propose to distinguish four types of metaphors within a learning environment, according to which part of the environment is concerned by the metaphor:

- *Design metaphors*: metaphors used during the design process of the learning environment by the designers in order to think about the system.
- *Interface metaphors*: metaphors at the user interface level, can be perceptible by the learner.
- *Scenario metaphors*: metaphors used in the instructional scenario.
- *Content (or instructional) metaphors*: metaphors used to explain topics of the subject matter.

Research on scenario and content metaphors in the framework of computer-based learning environment, seems to be quite new. Indeed, those metaphors have been studied in traditional training situations but without computer based learning environment.

A general schema of the categories is presented in (Figure 1). In the following sections, we define more precisely the categories, subcategories and we give examples for each one (Table 1).

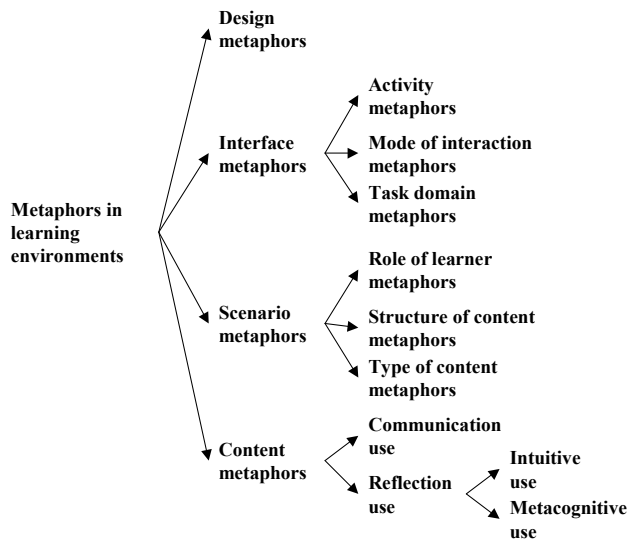


Figure 1: Categories of metaphors

### 3. Design metaphors

Design metaphors are the metaphors used by the designers during the design process of a system in order to reflect to the functionalities of the whole system (not only the interaction with the user). They can also be used by future users of the system when they participate to the design process. A classic example is to consider a word processor as a type writer (Table 1).

Madsen [17] studied those metaphors and gave guidelines in order to generate potential metaphors, to evaluate them and to develop them in the design task. For example, three potential metaphors were studied in the design of computer applications for a library: library as a warehouse, as a store or as a meeting place (Table 1). Each metaphor implies a different vision of what is a library and of what are the services offered: the warehouse metaphor is the base of classic software for libraries while the meeting place metaphor could be used to design systems improving communication between readers.

The field of hypermedia design is especially rich with metaphors. For example Bernstein [3] distinguishes three types of hypermedia and explains them by three metaphors: information mining, information manufacturing and information gardening (Table 1).

In what concerns design metaphors for learning environments, research seems to be quite rare. An example is though provided by the research of the Memolab project [9]. A pyramid metaphor is used to represent the concepts and skills to be acquired by learners, learning consist in moving up the pyramid (Table 1). The role of this metaphor is to translate psychological principles into design principles. An other common design metaphor is to consider a distance learning system as a virtual campus (Table 1).

In fact, it seems there is little research on design metaphors, compared to interface metaphors.

### 4. Interface metaphors

Interface metaphors are the metaphors at the user interface level of the computer-based system. The aim of those metaphors is to help the end-user to better interact with the system. Metaphors should refer to familiar domains, so that the user can improve his understanding of how operate the computer with knowledge already acquired. The most famous example is the desktop metaphor present on all current personal computers.

There are several possible classification of interface metaphors, as reviewed by Neale & Carroll [20]. One of the most general is given by Hutchins [14], he distinguishes three levels of metaphors:

- *Activity metaphors*,
- *Mode of interaction metaphors*,
- *Task domain metaphors*.

Activity metaphors concerns the user's highest goals, like learning, communicating or searching information. For example a frequent metaphor for learning is the construction of a house (Table 1).

Mode of interaction metaphors concerns the interaction between the user and the computer, it relates to how the user views the computer. For example the user can view the interaction with the system as a conversation

with another person or as a declaration on a world (like magic incantations) [14] (Table 1). Those metaphors are independent from the task.

Task domain metaphors concerns the structure of tasks performed by the user. The most famous example is the desktop metaphor [23] (Table 1). Another famous example is "web surfing" which is a metaphor for browsing in an hypermedia (Table 1). Another metaphor for web surfing is used in Québec with a precise verb "butiner" (which means to gather nectar for bees).

Most of the work on interface metaphors has been done on task domain metaphors although the two other levels of interface metaphors are always involved [20]. Interface metaphors are most of the time presented to the user by pictures (like icons representing functions), so they are often *visual metaphors*. But sounds can also be used to give feed-back to users like in *auditory icons*, and there are some research on sounds as support for metaphors [6]. *Spatial metaphors* (like landscape, city, room etc.) are a kind of visual metaphors often used within hypermedia environments to facilitate navigation [8].

## 5. Scenario metaphors

Research in design of multimedia environments, probably due to the extended possibilities of visual presentations, has stressed the role of metaphors for creating a unifying context able to link the various elements of a domain knowledge. For example, computer is seen as a theater by Laurel [16], so as a narrative environment. More recently, those ideas were developed for multimedia learning environments [7], [13].

Those metaphors are aimed at presenting the structure of the content, at suggesting the nature of content, and at bringing the learner into learning activities, like by giving him a role. For example, the role of learner can be that the learner is an explorer in an unknown country, the country of the knowledge to be learned (Table 1). The structure of content in a multimedia on Egyptian civilization can be presented by the image of a museum (Table 1). If the topics of the knowledge domain are very linked one to each other, a network can suggest this nature (Table 1). Consequently those metaphors are related to the global instructional scenario.

Although nature of content (or type of content) metaphors are aimed at suggesting the content, we think that it is rare that they go deep into the content, that is why we would group them in scenario metaphors and distinguish them from content metaphors.

## 6. Content metaphors

Content metaphors, that could also be called instructional metaphors, are the metaphors used to facilitate understanding and memorization of the content of the training domain, that is, of the knowledge to be acquired. For example knowledge acquisition in electricity can be facilitate by using metaphors in water circuit (Table 1). Or acquisition of knowledge in computer networks can be facilitate by using metaphors in road networks, in postal system or railway network (Table 1).

The content metaphors involved in a learning situation with computer-based learning environment may exist in various places:

- In the learners' mind: spontaneous metaphors used by the learner to understand difficult topics;
- In the teachers' mind: metaphors used to teach difficult topics;
- In books, on the Internet;
- In the computer-based learning environment: metaphors implemented by the authors of the content of the environment;
- In the surrounding social environment: the social metaphors broadcast by medias (TV, newspapers, etc.). A recent example is the famous "information highway" metaphor;
- etc.

Content metaphors can be used in different ways, as stressed by Sticht [24]. Although this classification was defined for learning situation without computer, we think it can be applied to our matter.

As a *communication tool*, metaphor is used as a linguistic tool which helps to bring back information into active memory of the learner, as theorized by Ortony [21]. In this case the learner doesn't realize any learning activity based on metaphors, this situation is like the very common use of metaphors in a classroom when a teacher gives a lecture. In computer-based learning environments, this is like the quite frequent use of metaphoric pictures in multimedia environments illustrating a specific topic.

On the contrary, metaphor as a *reflection tool* implies that the learner realizes activities based on metaphors. Two cases are distinguished: in the case of analogies as *intuitive tool*, metaphors are underlying learning activities but are not explained. In computer-based learning environments, this is like the use of metaphors in simulations or games: metaphors exist but are not explicitly studied by the learner.

In the case of metaphor as a *metacognitive tool*, metaphors are explained: the relations between the knowledge domains are analyzed by learners (the adequacy as well as the limits) with specific learning activities. According to Sticht, this use stimulates creation of knowledge and not only retention, and also extends the capabilities of analytical thought. As far as we know,

there are very few systems based on metaphors as a metacognitive tool.

One example is the prototype AMPS, Analogical Model based Physical System of Brna & Duncan [2]. This system is based on a simulation of each domain of the metaphor, for example, a simulation of electrical circuits and water circuits. The learner constructs a circuit in each domain and defines the properties of its components with editors. Then he/she can simulate each circuit and compare the two simulations.

Another example is our PhD thesis [18] [19], which describes a learning environment based on metaphors, hypermedia and concept maps where learners can navigate from one knowledge domain to another through hypertext links, choose among several metaphors, and construct concept maps indicating those metaphors and reflecting their comprehension of the field.

Type of metaphor	Target domain	Source Domain
<b>Design metaphors</b>		
Design	Word processor	Type writer
	Library system	Warehouse
		Store
		Meeting place
	Hypermedia system	Mine
		Manufacture
Garden		
Learning	Moving up a pyramid	
Distance learning system	Virtual campus	
<b>Interface metaphors</b>		
Activity	Learning	Construction of house
	Communicating	Weaving
Modes of interaction	How the user views the interaction with a computer	Conversation
		Declaration
		Model world
		Collaborative manipulation
Task domain	Files management	Desktop : files, trash can, etc.
	Cut function in a word processor	Cut with scissors
	Hypermedia browsing Web browsing	Navigation
		Surf
Communication space	Gather pollen (bees)	
Communication space	Coffee room	
<b>Scenario metaphors</b>		
Role of learner	Explore the knowledge	Traveler in an unknown country
Structure of content	Structure of Egyptian civilisation material	Museum
Nature of content	Linked knowledge	Network
<b>Content metaphors</b>		
Content	Electrical circuits	Water circuits
	Computer network	Road network

		Postal system
		Railway network
	Internet	Highway (Information Highway metaphor)

Table 1: Examples of metaphors in categories

## 7. Relations between categories of metaphors

Further work needs to be carried out in order to precise the relations between categories of metaphors. We indicate below some questions on this topic.

*Design metaphors and interface metaphors:* how are interface metaphors resulting from (implicit or explicit) design metaphors? Are all design metaphors becoming "visible" through task domain interface metaphors?

*Interface metaphors and scenario metaphors:* some scenario metaphors are probably related to activity metaphor, the most general activity being here learning.

*Interface metaphors and content metaphors:* content metaphors could probably be somehow related to the task domain type of interface metaphors.

*Scenario metaphors and content metaphors:* How deep is the connection between the two categories?

*Content metaphors and design metaphors:* In what extent are content metaphors coming from design metaphors ? In effect, content metaphors can be created by teachers specifically for training purposes or can be older metaphors, created by researchers: for example, the postal metaphor was used by computer networks researchers in the 70's and is now used by some teachers. In this sense, when the domain to be learned is a technical system, content metaphors may result from past research design metaphors of the technical system.

In practise, we think that there are nowadays three main approaches for using metaphors in computer-based learning environments:

- Multimedia environments containing scenario metaphors with important visual presentation and few content metaphors. This is a frequent approach.
- Multimedia environments with visual content metaphors, used as communication tool. This is also a frequent approach.
- Learning environments with content metaphors used as cognitive tool, but without scenario metaphors (this approach enables the learner to choose among metaphors and even to create them). This is a seldom approach.

## 8. Conclusion

We proposed a first classification for clarifying the types of metaphors in computer-based learning environments. This classification could probably be more detailed and should be further tested with existing

learning environments containing metaphors at different levels.

This classification could be useful to describe metaphors in existing learning environments or to guide the design of future learning environments. In this case, an important research perspective is to study the benefits and limitations of each type of metaphor and appropriate time to use them, in order to give advice to designers.

For example, one question that arise is whether it would be a good idea to integrate several types of metaphors in the same environment. Is there a risk or not for the learner to be "mixed-up" with all those metaphors?

Another question is whether it is interesting to implement several possible metaphors for each category. The answer for content metaphors as cognitive tools is certainly yes: it is important that the user can freely choose among several metaphors the one he/she prefers (maybe the most familiar source domain). The possibility of choosing metaphors is also important due to social aspects of metaphors, because most of metaphors are culture dependant: they can be understood in one culture but not in another because the familiar source domain is different according the countries and/or cultures. So using various metaphors enables the learner to choose and also promotes cultural diversity.

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