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LOGICAL MEANINGS IN MULTIMEDIA LEARNING MATERIALS: A MULTIMODAL DISCOURSE ANALYSIS

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Abstract: Multimedia educational applications convey meanings through several semiotic modes (e.g. text, image, sound, etc.). There is an urgent need for multimedia designers as well as for teachers to understand the meaning potential of these artifacts and discern the communicative purposes they serve. Towards this direction, a hermeneutic semiotic framework is proposed, which provides a controlled vocabulary for describing the logical meanings among the components that constitute multimedia representations. The framework in turn is implemented in the analysis of some multimedia materials in order to detect the types of their components and the logico-semantic relations identified among them. Using that framework, teachers would be equipped with visual literacy skills for reading the logical meanings of multimedia learning materials and multimedia designers would be able to design their own applications with respect to the logical meanings they want to promote through them.

Key words: Multimodal Discourse Analysis, Genres, Multimedia Educational Aplications, Logical meanings

1. Introduction

With the term "multimedia learning materials" we mean digital educational artifacts that represent and organize information through the combination of several semiotic resources (e.g. text, sound, image, etc.). These artifacts can be tutorials, drills and practices, simulations, educational games, etc. The modern teacher must be equipped with visual literacy skills and knowledge for being capable of interpreting the several multimodal meanings conveyed by these digital materials. What is more, multimedia designers must be also equipped with visual literacy skills for promoting multimodal meanings that make their learning materials more coherent and effective. Multimodal Discourse Analysis (MDA) can be a helpful tool towards this direction. For MDA, people use particular meanings to communicate with each other in specific social contexts. These meanings are created through complex ψομβινατιονς οφ visual, verbal aural, gestural, three-dimensional and other semiotic resources (O' Halloran, 2008). MDA examines the ways several multimodal resources are integrated and interact with each other in specific social contexts (e.g. classrooms, online environments, etc.), in order to trigger several communicative functions (e.g. Unsworth, 2006; Jaipal, 2010; Karalis and Vorvilas, 2011). As regards multimedia learning material, semiotic resources can realize four kinds of meanings (O' Halloran, 2008):

- *Experiential meaning*, which concerns the ways the human experience of the world is visually or verbally represented in a multimedia message.
- *Logical meaning*, which concerns the informational linking between multimedia components.
- *Interpersonal meaning*, which concerns learners' engagement and interaction with multimedia representations.
- *Textual meaning*, which concerns the ways multimedia components are spatially and temporarily co-deployed on the multimedia representations' layout.

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In the present paper, through an analysis of several multimedia representations' examples (MR), we focus on the ways logical meanings are organized, particularly on the logico-semantic relations that exist among the several semantic components that constitute a multimedia representation.

2. Content aggregation of multimedia representations

But what kind of semantic components constitute multimedia artifacts? Vorvilas, Vergidis and Ravanis (2011) have been proposed a hermeneutic semiotic framework according to which the digital content of multimedia artifacts can be distinguished to two main semantic units: *items* and *clusters*. Items are phonic, musical, visual and linguistic components such as push buttons, submit buttons, radio buttons, checkboxes, sliders, table cells, menu items, headings, titles, phrases, sentences, icons, symbols, sounds, etc. Items can be interpreted as communicative acts that offer, ask or demand information or goods and services. In figure 1 (MR1, 2013) we have marked in dashed circles and ellipses three such items. Item 1 is a switch that the user can turn on/off (service offering). Item 2 is a phrase that offers information (Current (I)). Item 3 is a question that demands information.

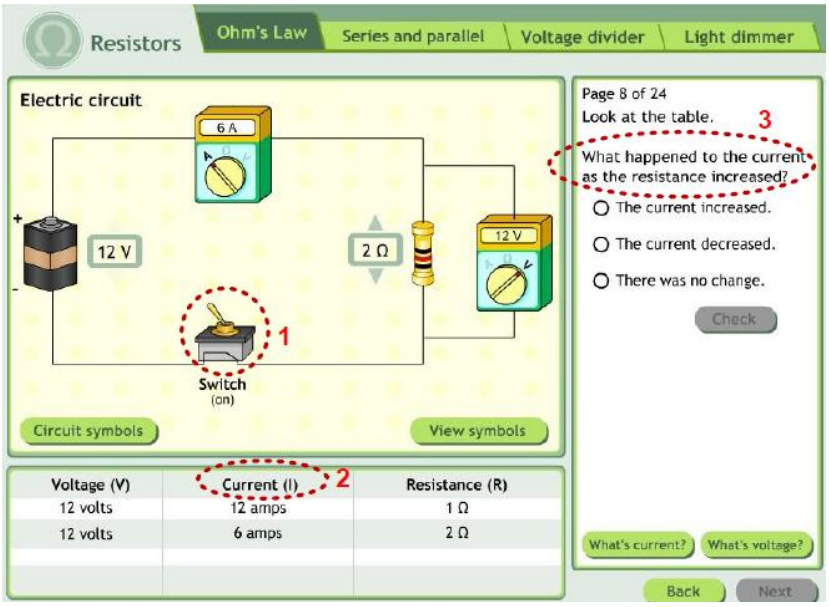


Figure 1. *Items in a multimedia learning material*

Items can stand alone or they can be combined with each other to create clusters. The notion of cluster is used here to define local groupings of components with particular communicative functions on the multimedia layout (Baldry and Thibault, 2006). Clusters extend from smaller-scale groupings to larger-scale groupings, thus we could speak of micro-clusters and macro-clusters with respect to the level of the whole / part relations we want to describe among groupings. The communicative functions of clusters often allow us to classify them in particular genres. Genres are, generally speaking, types of texts or images that serve particular communicative goals (Table 1).

Table 1. *Some genres and their communicative goals*

Genre types*	**Communicative goal**
Analytical representations	To represent several entities in whole / part relations.
Classificational representations	To represent several entities or phenomena through class / sub-class or co-class relations.
Narrative representations	To represent several actions, processes and changes.
Procedures	To tell someone how to do something.
Reports	To classify, describe or decompose several types of entities and phenomena.
Explanations	To explain why something happens.
Stories	To narrate, record or explain events and circumstances of the human life.

Questions-and-responses	To demand information from someone and provide him with the relevant feedback.

*Based on Kress and van Leeuwen, 2006, Martin and Rose, 2008, Allessi and Trollip, 2001

Speaking more technically, according to Baldry & Thibault (2006) a cluster can be interpreted as an instantiation of a genre type. In this respect, the notion of cluster help us recognize several groupings as exemplary cases of genre types, but it can also help us handle hybrid cases in which a grouping although it serves a communicative goal it remains unclassified as a genre type. In such cases a grouping that does not instantiates any well-known genre type can be simply called "cluster", without being attributed to any particular genre class. By well-known genres we mean here groupings that belong to a socially recognized genre classifying schema. From another perspective, we could say that clusters that are not classified under any particular genre class, they actually instantiate unclassified or unclassifiable genres (Santini, 2007).

Figure 2 depicts a cluster constituted of three sub-clusters marked in dashed rectangles (MR1, 2013). Sub-cluster a consists of items such as one question, five statements, three circles that stand for radio buttons and a "Check" submit button. It instantiates the "alternate response" genre (a sub-category of the "questions-and-responses" genre - see Allesi and Trollip, 2001). Sub-cluster b consists of images linked with lines, words and numbers and the submit buttons named "Circuit symbols" and "View Symbols". It instantiates the "analytical representations" genre. Sub-cluster c consists of a table with words and numbers accompanied with letters. It instantiates the "classificational representations" genre. The three sub-clusters together constitute a larger cluster in which they "co-operate" to help the user to extract information and submit his answer. That cluster cannot be classified with respect to the genre types presented in table 1 despite the fact that it serves a particular communicative function (it could also be considered that it might instantiate an unclassified or unclassifiable genre).

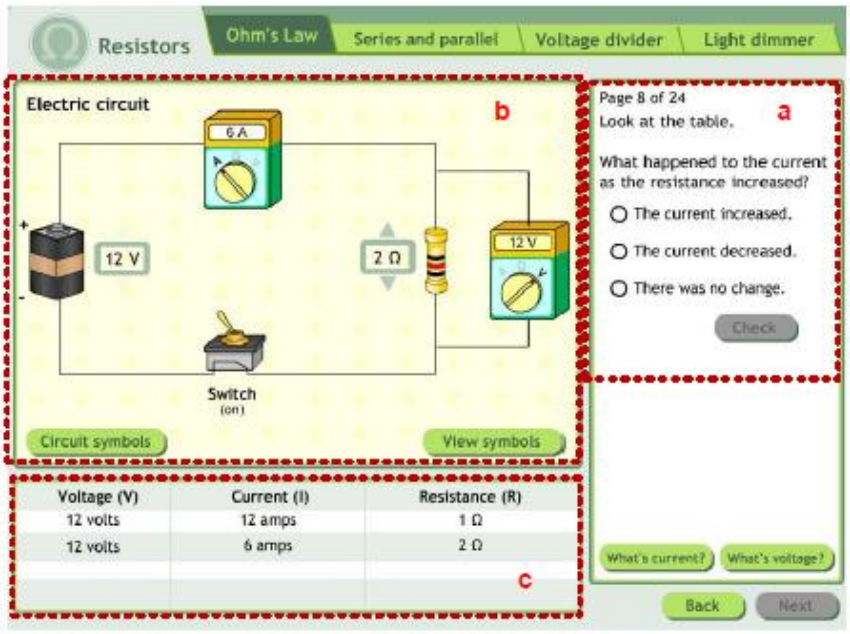


Figure 2. *Clusters in a multimedia learning material*

3. Logical meanings between multimedia components

The meaningful information linking among components (items, clusters / sub-clusters) mentioned in the previous section, can be achieved through the logico-semantic relations of elaboration, extension, enhancement and projection, which can be traced through the

deployment of multimodal texts in general (e.g., Lemke, 2002; van Leeuwen, 2005; Djonov, 2005; Kong, 2006; Martin and Rose, 2008; Vorvilas, Karalis and Ravanis, 2010; Vorvilas, Vergidis and Ravanis, 2011).

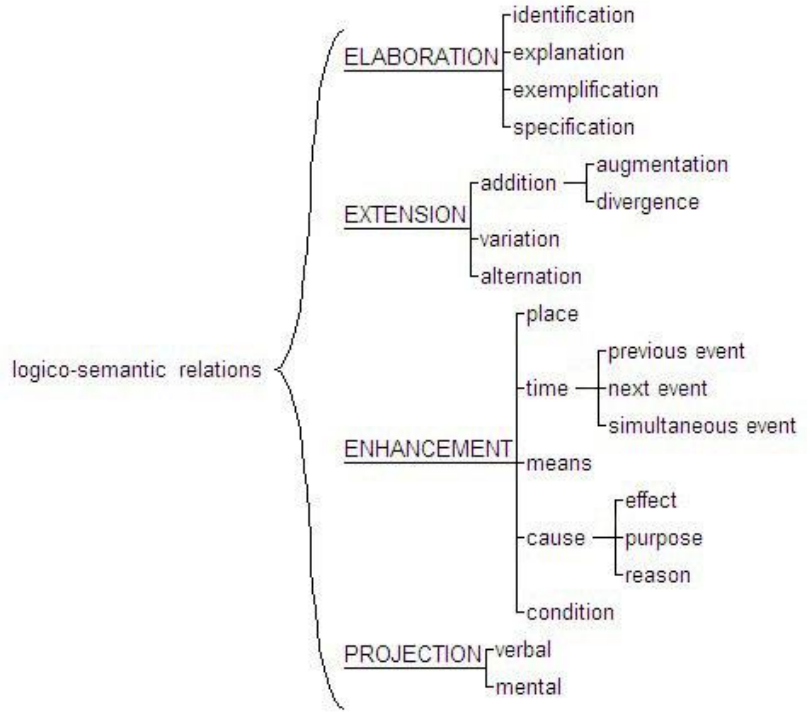


Figure 3. *A system of the logico-semantic relations between multimedia components*

3.1 Elaboration

In elaboration one component elaborates the meaning of another, by describing it in detail, exemplifying it, clarifying it or restating it. Sub-categories of elaboration are: *identification*, *explanation, exemplification* and *specification* (Figure 3).

Many times within a multimedia representation, readers must recognize several entities. Kong (2006) has used the term "identification" to underline the function of naming within a multimodal document.

In explanation, one component explains the meaning of another through a different semiotic mode. Kong (2006) and van Leeuwen (2005) have used this term to describe cases in which one component restates the meaning of another. Martinec and Salway (2005) and Unsworth (2007) have used the term "exposition" to describe the same logico-semantic relation.

Kong (2006), Martinec and Salway (2005) and Unsworth (2007) refer to the term "exemplification" to describe cases in which textual and pictorial components exemplify each other. In such cases the related components differ in generality, e.g. the textual component might be more general and the visual component might be more specific.

Djonov (2005), Kong (2006) and van Leeuwen (2005) have used the term "specification" to underline the fact that one component can elaborate in detail the meaning of another. Djonov (2005) has pointed out that in specification the message of a component is elaborated by another through a shift in the degree of abstraction, given the fact that a transition from a more general to more specific information takes place.

A variation of specification is the "overview / detail" relation (van Leeuwen, 2005), also described as "reinforcement" (Djonov, 2005). The "overview/detail" relation refers to the visual enlargement of several components within a multimodal representation.

3.2 Extension

In extension, one component extends the meaning of another by adding new information, giving an exception to it or offering an alternative. Sub-categories of extension are: *addition*, *variation* and *alternation.*

In addition, one component expands the meaning of another by adding new information which functions either in a complementary or a contrasting way. van Leeuwen (2005) has used the term "similarity" to describe the relation among filmic components when they share a similar information with respect to the content they represent. He has also used the term "contrast" to describe the relations among components when their meanings are in antithesis or contradiction. Djonov (2005) has also used the same terms to describe logico-semantic relations between hypertext components. Unsworth (2007) has made a distinction between "augmentation" and "divergence", which we adopt here to describe logical meanings of addition. In augmentation, one component expands the meaning of another by adding new information. Divergence refers to cases in which several components deploy in parallel dissimilar and sometimes contradictory messages.

Kong (2006) has used the term "variation" to describe relations of comparison / contrast among the messages of several components. Also, Kong (2006) has used the term "alternation" to describe cases in which one component replaces the meaning of another by providing alternative information that does not thoroughly changes the meaning of the original component.

3.3 Enhancement

In enhancement one component expands the meaning of another by enriching it with new information through circumstantial features of *place, time, means, cause* and *condition*.

Djonov (2005), Martinec and Salway (2005) and Unsworth (2007) have used the term "place" to describe enhancement through information about time and Kong (2006) uses the term "spatio-temporal enhancement".

In order to describe temporal / logical sequencing among components, van Leeuwen (2005) has used the terms: "previous event", "next event" and "simultaneous event".

In the logico semantic relation of means one component functions as a means for doing something related to another component. Kong (2006) has used the terms "manner" and "means" as sub-categories of enhancement in general and Djonov (2005) has classified "means" as sub-category of the "cause" relation. Unsworth (2007) has used the term "manner" as sub-category of the "means" relation.

Among multimedia components we distinguish three cases of cause relations: *effect*, *purpose* and r*eason*. In logico-semantic relations of effect (Kong, 2006), one component depicts, describes or shows the effect of an action (cause) described, depicted or triggered by another component.

In the logico-semantic relation of purpose one component expresses an activity to be initiated in order to realize an intended situation with respect to another component (RST, 2014). The logico-semantic relation of purpose has been used by Kong (2006). Martinec and Salway (2005) have also regarded purpose and reason as sub-categories of causal enhancement.

In logic-semantic relations of reason, a component explains why something described or depicted by another component happens. Djonov (2005) and Martinec and Salway (2005) have classified this relation as sub-category of "cause". Djonov (2005) has reported as examples of reason relations in hypertext, cases in which the user takes feedback that explains why a specific choice he made was right or wrong.

In the logico-semantic relation of condition, one component functions as a conditioning situation with respect to another component whose occurrence results from the occurrence of the conditioning situation (RST, 2014). This relation is mentioned in Unsworth (2007) for describing image-text relations.

3.4 Projection

In projection the meaning of a component appears through another component either as idea or locution. When the second component of relation represents thoughts, projection is mental. When it represents speech, projection is verbal.

4. Implementing the hermeneutic framework

In this section, the semiotic framework described above is implemented in the analysis of several multimedia applications in order to detect the logical meanings among their components. Our analysis was based on examples from *Wisc-Online* and *Flexible Learning Toolboxes* repositories which provide a variety of open multimedia learning resources.

4.1. Identification

In figure 4, we can see an example of identification relation among components. The list of items (labels) depicted on the right side of the screen identify the organelles' names of the animal cell (analytical representation), each time the user rolls the cursor over several parts of the animated image (MR2, 2013).

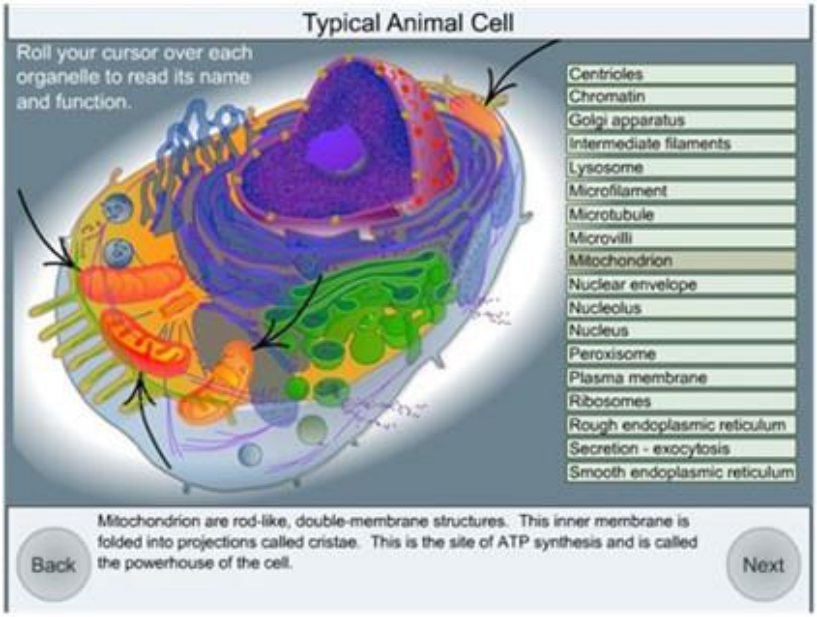


Figure 4. *An example of identification*

4.2. Explanation

In figure 5, we can see an example of explanation: sub-cluster a (an instance of the "explanations" genre) explains the meaning of sub-cluster b (an instance of the "narrative representations" genre) by restating what exactly happens when the user increases pressure inside the piston by dragging the slider (MR3, 2013). Explanation relations can also be detected in figures 14 and 16, where the textual components (short sentences) explain the animated images.

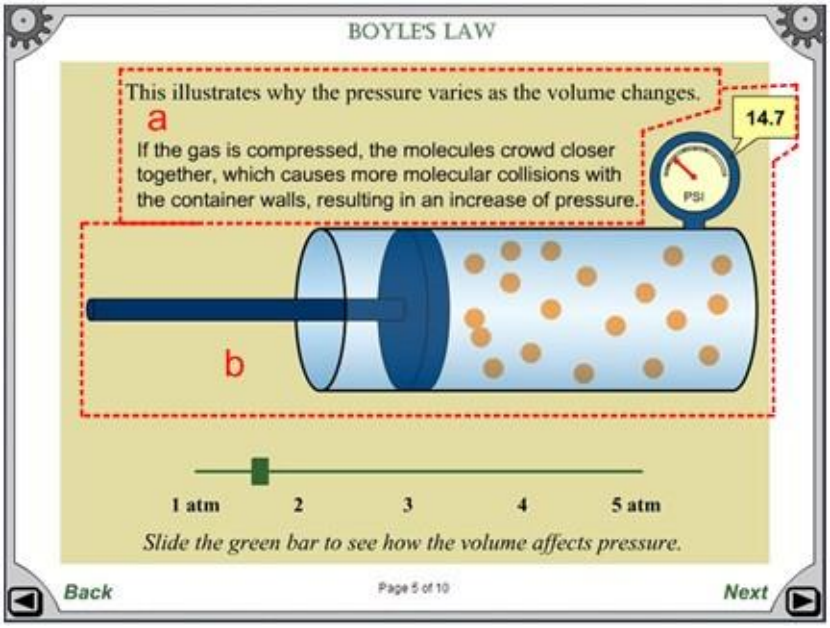


Figure 5. *An example of explanation*

4.3. Exemplification

In figure 6, the textual component a (an instance of the "reports" genre) describes the calyx and corolla of flowers. The pictorial component b (an instance of the "analytical representations" genre) functions as an example of the general class "flower" to which the textual component refers (MR4, 2013).

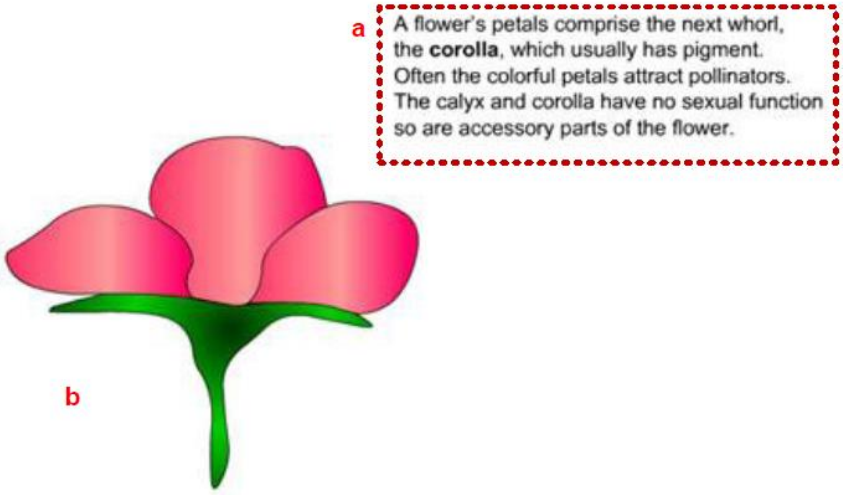


Figure 6. *An example of exemplification*

4.4. Specification

In figure 7, we can see an example of specification. In the open window in a tutorial's environment, the user can click on each one of the components (circuit symbols) depicted on the left side of the window so as to take detailed information on the right side. For example, when the user clicks on component a, the new sub-cluster b appears on the screen (an instance of the "reports" genre) providing him with detailed information about the meaning of the word "Transistor". (MR1, 2013).

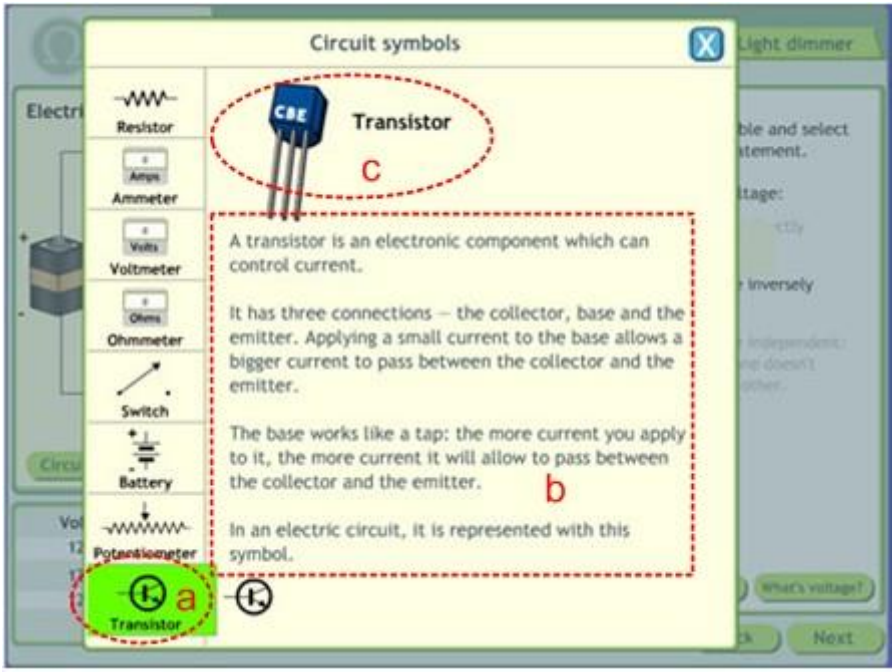


Figure 7. *An example of specification*

An example of specification through the overview / detail device can be seen in figure 8: image b (analytical representation) provides a detailed elaboration of image a (analytical representation) by zooming in a part of it (MR5, 2013).

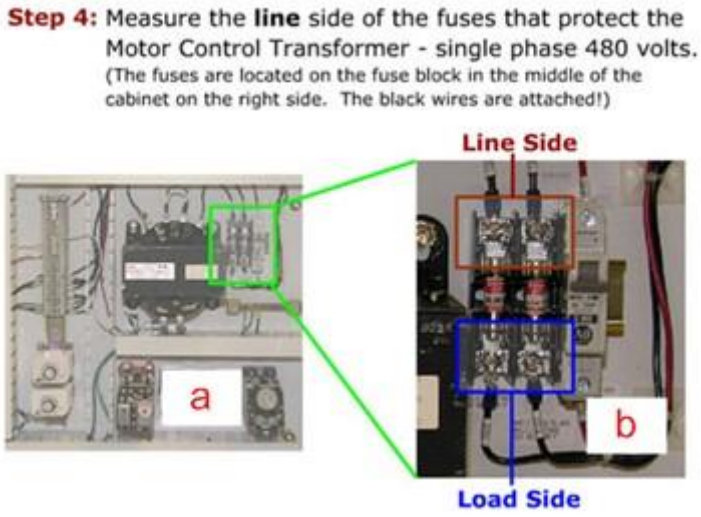


Figure 8. *An example of specification (overview / detail)*

4.5. Addition

In figure 9 we can see an example of augmentation. The depicted cluster consists of two sub-clusters: sub-cluster a (an instance of the "reports" genre) and sub-cluster b (an instance of the "narrative representations" genre). Both sub-clusters augment each other's meaning since each one carries information not mentioned to the other. For example, sub-cluster b depicts information about the sexual lifecycle of plants not mentioned in sub-cluster a. Sub-cluster a also refers to information largely not depicted in sub-cluster b (MR6, 2013).

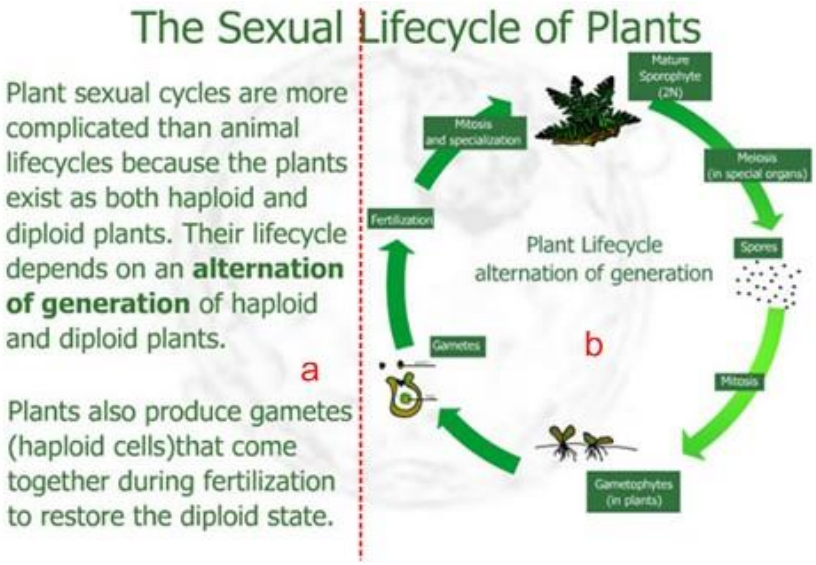


Figure 9. *An example of addition (augmentation)*

An example of divergence can be seen in figure 10: sub-cluster a (an instantiation of the "reports" genre) describes several aspects of plants and sub-cluster b (an instance of the "analytical representations" genre) depicts a shot of forest vegetation. Both sub-clusters deploy in parallel messages that differ in content (MR7, 2013).

Figure 10*. An example of addition (divergence)*

4.6. Variation

In figure 11, image b identified by the "Side View" item functions as a variation of image a identified by the "Top View" item. The user can compare / contrast two views of the same switch and its parts. Another example of variation can be seen in figure 14 between sub-clusters a and b, where two voltmeters move simultaneously, although in different speed, towards two magnetic fields. The two animated images promote their comparison / contrast since the user can observe that the faster the speed of the wires when they move through the flux the more the voltage increases and vice versa (MR5, 2013).

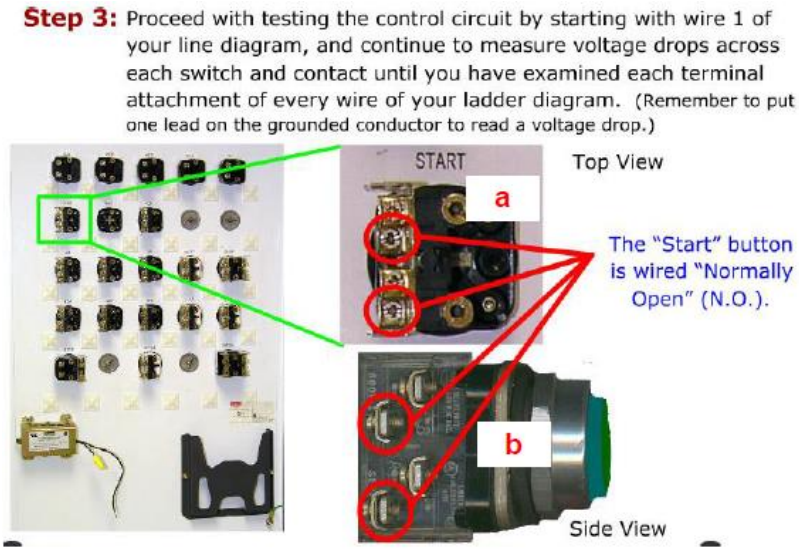
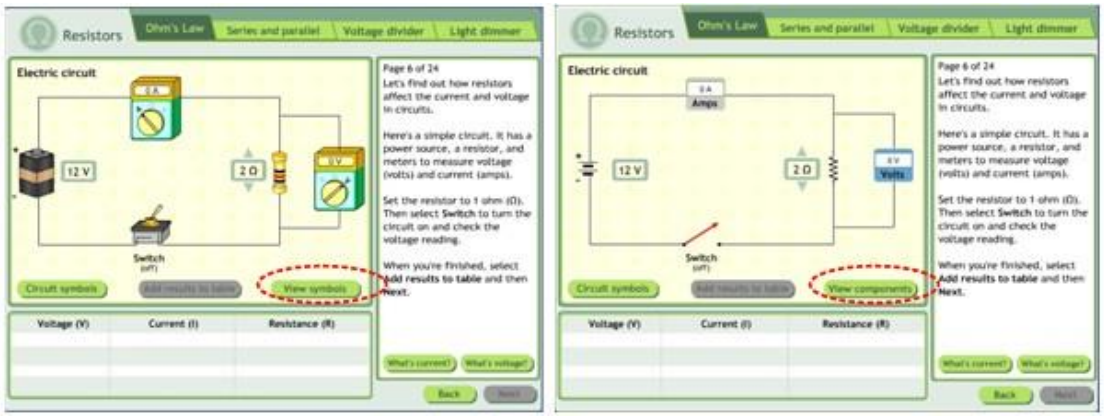


Figure 11. *An example of variation*

4.7. Alternation

An example of alternation can be seen in figure 12, through the alternate "View symbols" and "View components" items (marked in dashed ellipses). Two different sub-clusters (analytical representations) of the same circuit can be depicted when the user clicks on these buttons: a "hybrid representation" (figure 12a), where the depicted items are close to the photorealistic code of picturing, and a "symbolic representation" (figure 12b), where the items are depicted through symbols that are used for representing them in the field of Physics (see for details: Dimopoulos, Koulaidis and Sklaveniti, 2003). The two representations are alternative ways to represent an electric circuit (MR1, 2013). The same relation can be also detected between components a and c in figure 7.



a b

Figure 12. *An example of alternation*

4.8. Place

An example of spatial enhancement between components can be seen in figure 13. A map is depicted (an instance of the "analytical representations" genre), in which a storm is identified by the "Tropical Storm Erin" item (MR8, 2013). The storm is located in the Atlantic Ocean near the Turks & Caicos Islands and on the above right part of the representation a blue box with a list of items offers (among other things) information relevant to the location the storm evolves ("Latitude: 22.3 North", "Longitude: 73.2 West").

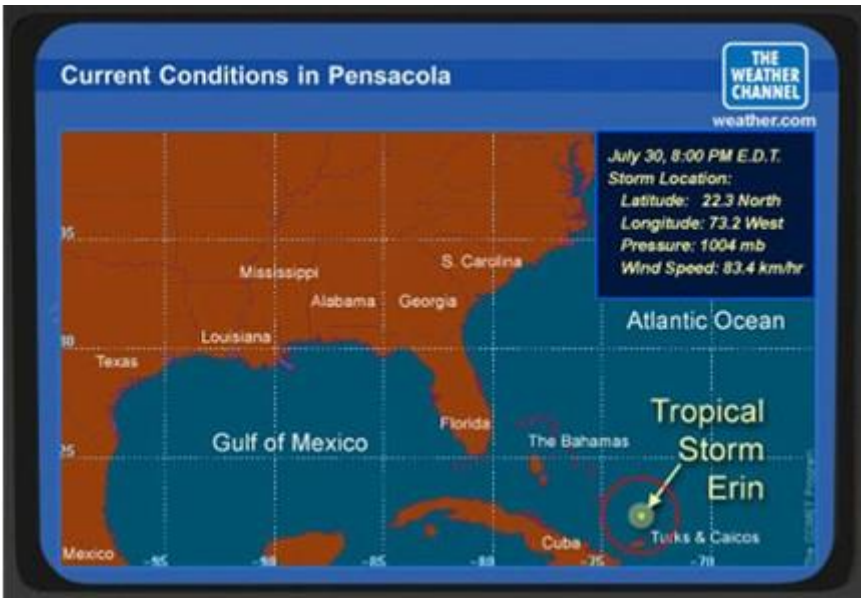


Figure 13. *An example of spatial enhancement*

4.9. Time

Examples of previous and next event between multimedia components can be seen in figures 1, 4 and 5 where the "back" and "next" buttons are the items that allow the user to go forth and back between screens. In figure 14 sub-clusters a and b (instances of the "narrative representations" genre) are linked to each other through a "simultaneous event" relation because by clicking on the "Move Wire Down" button, the user starts an animation in which two voltmeters move simultaneously (although in different speed) towards two magnetic fields (MR9, 2013).

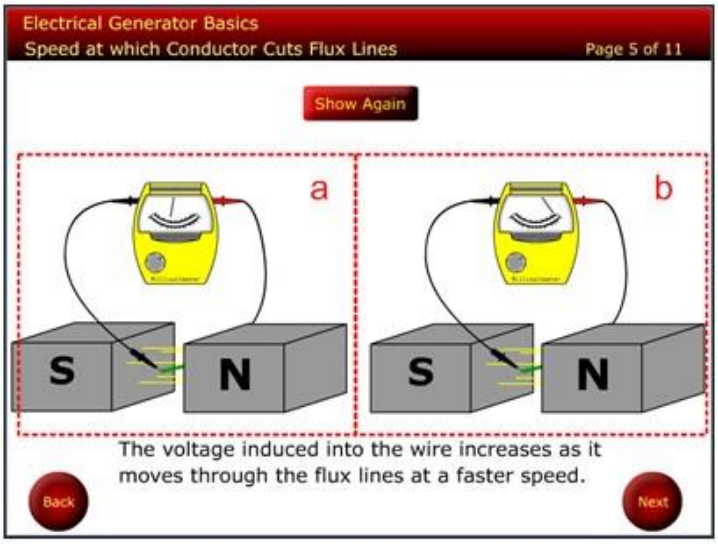


Figure 14. *An example of a simultaneous event*

4.10. Means

In figure 15 the user can drag item a (a slider) so as to increase or decrease the pressure inside the piston (sub-cluster b). This is an example of means relation between the instrument (slider) and sub-cluster b (MR3, 2013).

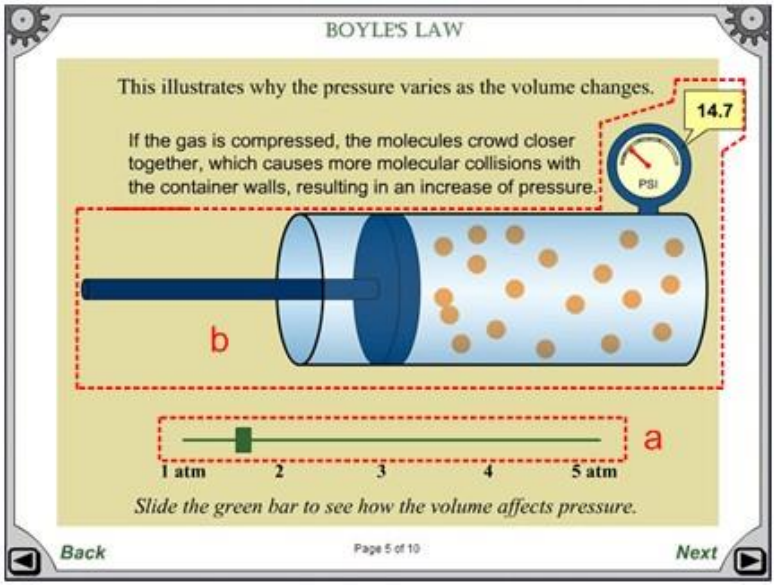


Figure 15. *An example of a means relation*

4.11. Cause

An example of effect relation can be seen in figure 16: the user, by clicking the "Show Contact" button, sets in motion a moving object (item a) which touches and moves a lever. The result is the activation of cluster b (an electric circuit which instantiates the "analytical representations" genre) (MR10, 2013).

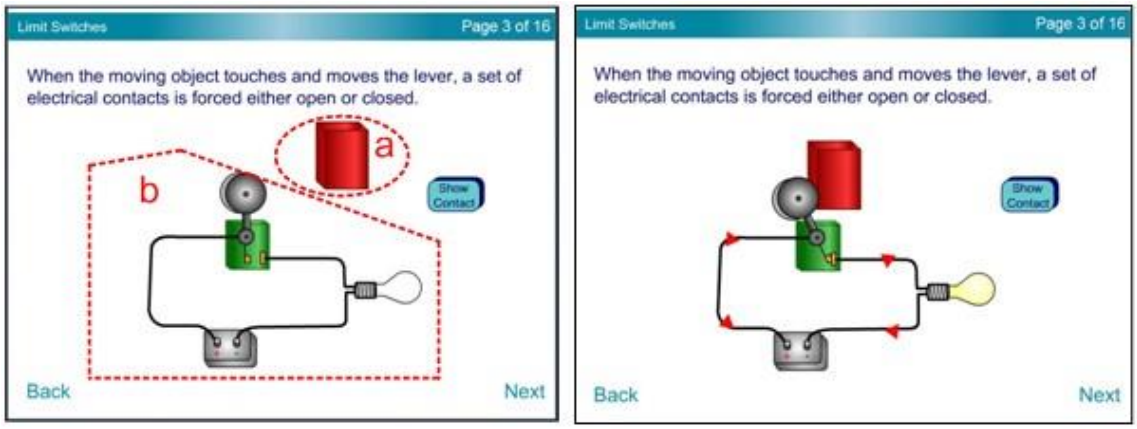


Figure 16. *An example of a cause-and-effect relation*

In figure 2 we referred to sub-cluster a (a "questions and responses" genre). When the user there clicks on the "submit" button he receives the answer depicted here, in figure 17. A small window informs him that his answer was correct (item a). A short text (sub-cluster b: an instance the "explanations" genre) explains the reason that item a holds true (MR1, 2013).

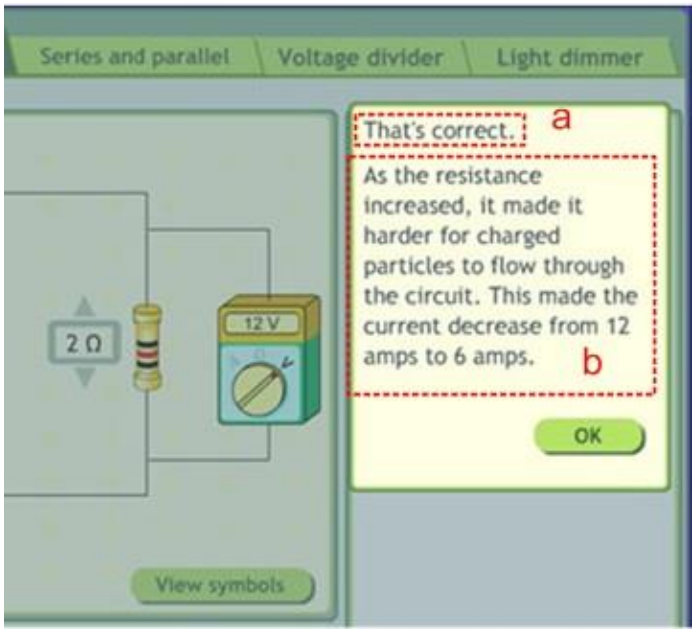


Figure 17. *An example of a cause relation (reason)*

Figure 18 (detail of figure 4) gives us an example of purpose relation. Item a express an activity to be initiated in order to realize the intended situation of reading the organelles names that correspond to parts of the animated image of the cell. (MR2, 2013).

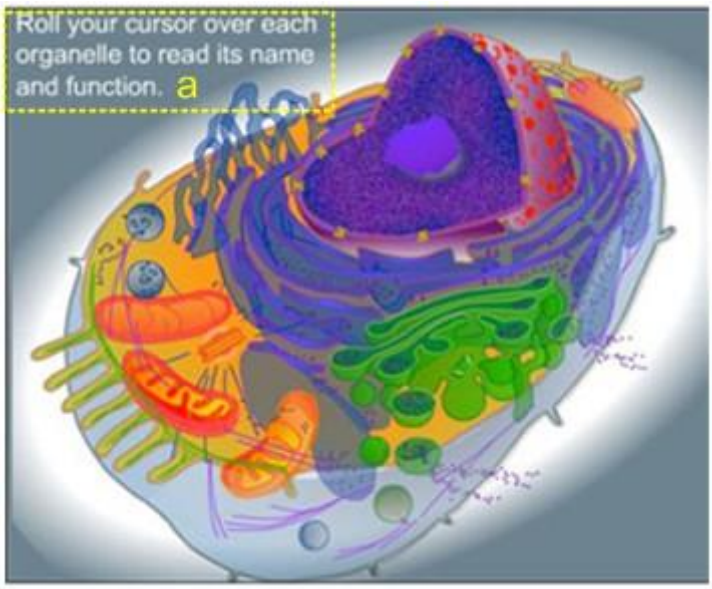


Figure 18. *An example of a cause relation (purpose)*

4.12. Condition

An example of condition can be seen in figure 19. The user must give an answer to the "alternate response" genre (cluster a), that is, he must click on either the "True" or the "False" checkbox (conditioning situation) in order to go to the next screen, by clicking on the arrow button, otherwise he cannot continue because the arrow button is deactivated (MR11, 2013). The activation of the arrow button results from the occurrence of that conditioning situation.

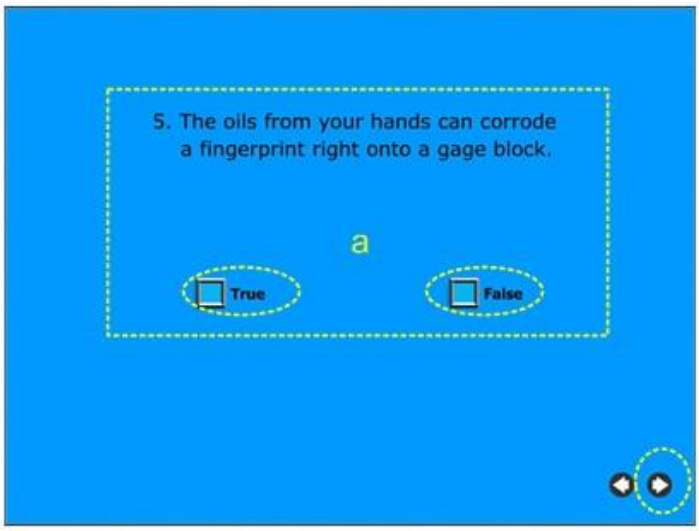


Figure 19. *An example of condition*

4.13. Projection

Examples of projection can be seen in figures 20a and b. In figure 20a, the information included in the speech balloon functions as a verbal projection of the words spoken to the user by the male figure depicted on the left (MR12, 2013). In figure 20b the cloud functions as a mental projection of the thoughts made by the female figure depicted on the left (MR13, 2013).

Figure 20. *Examples of verbal and mental projection*

5. Conclusions

What we proposed in the present paper was a general hermeneutic framework based on main logico-semantic relations that promote the logical linking among the components of multimedia learning materials. The analysis of the aforementioned examples was indicative, given the fact that more relations can be detected between the components of the selected multimedia representations. What is more, the types of relations explained here are not exclusive. On the contrary several other types have been proposed by many researchers for the description of logical meanings (e.g. Guijarro and Sanz (2009); Liu and O'Halloran, 2009; Zhao, 2010; Chan and Unsworth, 2011; Vorvilas, Karalis and Ravanis, 2011). The aim of the aforementioned analysis was to review through examples a basic vocabulary that would enhance teachers' skills and knowledge in visual literacy, by making them aware of the meaning potential of multimedia learning materials and capable of identifying multimedia artifacts appropriate for their educational purposes.What is more, multimedia designers could be equipped with such a vocabulary in order to create and test learning materials (e.g. Vorvilas, 2012; Vorvilas, 2013) following basic principles of multimodal discourse analysis.

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