Handbook of Research on Collaborative Learning Using Concept Mapping

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Chapter 10

Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping

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ABSTRACT

In this chapter, we investigate, with an intersubjective epistemology approach, how a concept mapping software tool that integrates a typology of knowledge objects (nodes) and a typology of links mediates the process of meaning-making and of meaning-negotiation of a dyad of adult learners engaged in a collaborative concept mapping activity, more specifically in the context of a text comprehension task. This case study shows that the tool and its object-typed concept mapping language induce certain types of epistemic actions as well as the formation of diverse representational rules by participants, which were jointly and progressively elaborated by them in an intensive effort to share meaning.

INTRODUCTION

Combining the advantages of the learning strategy of concept mapping (CM) learning strategy with those of collaborative learning, collaborative concept mapping (CCM) has become a topic of interest for an increasing number of researchers in the field of education (Basque & Lavoie, 2006; Gao, Shen, Losh, & Turner, 2007; Kim, Yang, & I-Chun, 2005; Nesbit & Adesope, 2006).

A close examination of the methodologies of 39 studies reported in our own review of research in this field (Basque & Lavoie, 2006), along with over 20 additional studies reviewed since then, made it possible to pinpoint many differences in the structure of the CCM tasks proposed to learners by researchers. For instance, a list of concepts and/or links may be provided to subjects; links may be labelled or not; links may be arrowed or not; roles may be given by researchers to each member of the CCM group, communication constraints may be imposed, etc. Also, CM software tools, such as Inspiration, CMapTools, or others (some of them still being R&D products), are becoming increasingly popular. Actually, a total of 43 of the 65 studies that we investigated so far provided students with a
CM software tool, either in a face-to-face context (21 studies) or at a distance (24 studies). In this chapter, we argue that the CM tool and the CM method used in CCM activities can significantly affect the processes of meaning-making and that of meaning-negotiation amongst learners and, consequently, upon learning that may result from such activities.

The idea that CM software are “cognitive tools” (Kommers, Jonassen, & Mayes, 1992; Lajoie & Derry, 1993) or “mindtools” (Jonassen, 2000) to the same extent as databases, microworlds or visualization tools was put forth by Jonassen in the beginnings of the nineties (Jonassen, 1992). Such tools facilitate external representations of information and enhance cognitive functioning (Kommers, Jonassen, & Mayes, 1992; Olson, 1985). This notion of cognitive tool is somewhat similar to the notion of “cognitive artefact” proposed in the field of Human-Machine Interaction by Norman (1991) and by other authors involved in Computer-Supported Collaborative Learning (CSCL) (Suthers, 2006) or working within the Activity Theory framework (Engeström, Miettinen, & Punamäki, 1999). Such a notion acts as a kind of “boundary object” (Star & Griesemer, 1989) for researchers from different fields sharing the idea that external knowledge representation tools guide and influence the learner’s activity and, thus, must be considered when investigating potential learning benefits. In the field of CSCL, Suthers (2003) suggested the expression “representational guidance” to refer to the fact that the properties of cognitive tools constrain which knowledge can be expressed in a shared context, and, in making some characteristics of that knowledge more salient, promote certain types of “epistemic actions” to the detriment of others.

In this chapter, we investigate how a CM tool that integrates a typology of knowledge objects and a typology of links mediates the process of meaning-making and of meaning-negotiation of learners engaged in a CCM activity, more specifically in the context of a text comprehension task.

**BACKGROUND**

We view the CCM activity as a tool-mediated intersubjective meaning-making activity (Suthers, 2006). Our approach is based then on what Suthers (2006) calls an “intersubjective epistemology”, which differs from an “individual epistemology”. In the latter, the individual is the unit and the agent of learning, and collaboration simply provides learning conditions and support. Although it is stimulated by social interactions, the cognitive process remains predominantly individual. In the former, the group is the unit of learning, within which “interpretations can be jointly created through interaction in addition to being formed by individuals before they are offered to the group” (Suthers, 2006, p. 317). Intersubjectivity also includes a participatory component: “it is a simultaneous process of mutual constitution that may involve disagreement as well as agreement about shared information” (Suthers, 2006, p. 317) and is comparable to a “polyphonic nonharmonious concert characterized by synchronic movements, as well as by distinct, conflicting and dissonant voices” (Smolka, De Goes, & Pina, 1995, in Suthers, 2006, p. 317).

This intersubjective meaning-making activity is a tool-mediated activity, which means that it is situated in a socio-cultural environment where tools and signs are imbricated with actions and thinking that provide them with meaning (Vygotsky, 1978). According to Vygotsky, qualitative transformations induced in the cognitive activity through “psychological tools” or “cultural tools” constitute the main factor of cognitive development and learning in a given socio-historical context.

Our theoretical position thus leads us to suggest that in order to define how a CCM activity can prompt or hinder learning, we must (1) study the communication and collaboration processes
which take place among the partners involved in the activity, such processes being closely linked to the joint actions undertaken and (2) consider the representational properties of the tools used in the CCM activity.

As for Suthers (2006), intersubjective learning has not yet been sufficiently explored in work conducted in the field of CSCL. We think that this is the case in the specific field of computer-based CCM in educational contexts. Studies in this field seldom go beyond categorization of social interactions occurring during the learning activity, without associating them with the participants’ joint actions and without taking into account the dynamics of the interactional process. The influence of the representational properties of tools on the process of co-construction of knowledge is also neglected in most of these studies.

In the following paragraphs, we first delve into the representational properties of CM software tools and techniques. Then, we present results of some studies on CCM, more particularly those conducted in face-to-face learning contexts, since such modality is addressed in this chapter.

Representational Properties of Concept Mapping Techniques and Software Tools

The CM technique developed by Novak (1990; Novak & Gowin, 1984) based on Ausubel’s (1968) theory of “meaningful learning” became a reference for most CM research and applications carried out in the field of education. A “standard format for concept maps” according to this technique was presented in 1992 at the National Convention of the National Science Teachers Association in the U.S.A. (Wandersee, 1992), and some of the most popular CM tools (e.g. CMapTools, Inspiration, SemNet) have been designed or are used according to this technique.

Basically, this technique uses a knowledge representation language composed of two main types of “primitives”: nodes and links. When combined, these two elements make it possible to create a graphic representation of a field of knowledge organized into a hierarchical network. Each node of the network represents a concept defined as “perceived regularities or patterns in events or objects, or records of events or objects” (Novak & Canas, 2006). Each concept is designated with one or a few words. Links among knowledge objects are represented with arrows, on which concept mappers add their own “linking words” (Novak, 1990). Two concepts connected through a labelled link constitute a “proposition”.

In this technique, minimal constraints are placed on the process of naming concepts and links, except that the concepts must be designated with nouns and the links usually with verbs, and that a special link (e.g.) is used to designate “examples” of some concepts. However, the map structure is constrained. The most general concepts must appear at the top of the map, and the more specific concepts must be placed at the bottom. Hence, the spatial layout and the directions of the arrowed links aim to express the idea of a hierarchy of concepts, going from the most general to the most specific ones. According to Novak & Gowin (1984), representing a knowledge domain in such a way enhances meaningful learning (Ausubel, 1968).

However, numerous researchers slightly modify this technique and pre-structure the activity by providing participants with a predefined list of concepts, nodes or both. Such is the case for almost half of the 65 studies we examined. Most researchers fail to justify this task organisation in their publications, probably most of the time for practical reasons rather than theoretically founded ones. Indeed, since language ambiguity can be reduced with the use of pre-labelled nodes and links, it becomes easier for researchers to evaluate the maps produced by learners. In other cases, such a strategy could have been used to decrease the time span of the experiment or to alleviate the level of difficulty of the task (for instance, with children or with learners creating
Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping

Nonetheless, a few researchers clearly opt for an explicit theoretically-driven position on this issue, arguing that, when the goal is learning, it can be beneficial to constrain the CM activity in some way to guide learners through this cognitively challenging task.

Many authors agree that the greatest difficulty for learners in creating concept maps resides in structuring concepts into a coherent collection, that is, in representing relations among concepts through labelled links (Basque & Pudelko, 2003; Canas, Valerio, Lalinde-Pulido, Carvalho, & Arguedas, 2003; Faletti & Fisher, 1996; Fisher, 1990; Novak & Gowin, 1984). Jo (2001) reports that students tend to use very general terminology to label links, which may suggest rather superficial thinking. According to Fisher (1990; Faletti & Fisher, 1996), one of the reasons is that school settings focus on teaching isolated concepts rather than structuring them into complex conceptual representations.

For those who consider learning as a process of building knowledge structures of increasing complexity, creating concept maps with a limited set of field-independent links would be a good strategy to enhance learning (Holley & Dansereau, 1984a; Kharatmal & Nagarjuna, 2006). For instance, the networking strategy proposed by Holley & Dansereau (1984a) support comprehension of scientific texts includes six types of links to represent not only hierarchical knowledge (type of/example of; part of), but also chains (leads to) and clusters (analogy, characteristic, evidence) of knowledge. The limit imposed on the link representation process would help in disambiguating natural language used to designate links, in making students more aware of the existence of various types of relations between knowledge objects (for instance hierarchical, mereological, temporal or causal) and in making different types of knowledge structures more salient for them.

Other researchers disagree with such a strategy arguing that, although certain relations can be considered as ubiquitous across domains, others remain domain-dependent (Faletti & Fisher, 1996). As Fisher (2000) puts it, “specialized knowledge requires specialized relations” (p. 155). Consequently, these authors believe that a constrained set of relations would severely limit the possibilities of expressing meaning.

In order to favour learning, other researchers propose guiding the CM activities with other knowledge representation constraints, which are actually some kind of “micro-structures” made up of a combination of typed links and nodes. For instance, Reader & Hammond (1994) led a study to compare constrained and non-constrained approaches to CM in an educational context. The participants, university students, had to create concept maps that represented the content and the arguments of a text on eating disorders. Students using the constrained approach were provided with a limited set of nodes (statements, proofs, critique, etc.), links (supports, contradict, etc.) and different types of predetermined propositional structures (for example, proof-support-statement is permitted, while proof-contradict-proof is not). The non-constrained approach imposes no restriction. The concept maps produced by participants using the constrained approach were more complete, more efficient in communicating the main ideas of the text and more compatible with the goal of the activity. More recently, Komis, Ergazaki, & Zogza (2007) compared the cognitive processes of a dyad of high-school students in two knowledge modeling conditions: a Novakian paper-and-pencil CM condition and a more structured computer-supported condition based on the use of the software ModelsCreator. In both situations, students were provided with a set of objects and properties pertaining to the topic of photosynthesis. However, within the ModelsCreator environment, they had to use, in addition, a limited set of semi-quantitative relationships (increases-increases; increases-decreases or increases-increases less). Researchers analyzed the students’ cognitive processes using a combina-
tion of the OCAF (Object-oriented Collaborative Analysis Framework) coding scheme to model basic operations (Avouris, Dimitracopoulou, & Komis, 2003) and the Stratford et al.’s coding scheme (1998, in Komis et al., 2007) for cognitive strategies. They found that ModelsCreator “mediated a discernable and more challenging learning environment than ‘paper-and-pencil’, especially in terms of self-assessment and monitoring, as well as moving towards a more mathematically informed understanding of photosynthesis” (Komis, Ergazaki, & Zogza, 2007, p. 1013).

Other studies showed the potential learning benefits of a constrained approach to creating different types of graphical representations of knowledge in small groups in an educational context. For example, Fischer, Bruhn, Gräsel, & Mandl (2002) investigated the social interactions between university students in Educational Psychology who created representations of three lesson plans in dyads, with either a graphic editor or a structured automated tool (CoStructure). The CoStructure tool provides a list of concepts pertaining to each lesson and it proposes two types of relations among concepts (positive and negative relations). Results show that the task structure provided by the tool encouraged dialogues on conceptual aspects of the task as well “conflict-oriented consensus building” discussions. The structure of the tool “represents a semantic coordinating element, which helps learners posing constraints in working on the case” (Fischer et al., 2002, p. 229).

Suthers and his colleagues (Suthers, 1999; 2001; Suthers, Girardeau, & Hundhausen, 2002; Suthers, Toth, & Weiner, 1997) led a set of studies on the use of a software tool called Belvedere. It makes it possible to construct “inquiry diagrams” or “evidence maps” (a special kind of concept maps) which relate data (empirical statements) and hypotheses (theoretical statements) with two types of evidential relations: for (consistency) and against (inconsistency). A data conjunction link is also proposed. Such investigations show that the representational or primitive properties of Belvedere constitute an ontology of categories and structures to organize the task domain and can have a significant effect on the learners’ knowledge-building discourse, on learning outcomes as well as on the content of students’ collaboration. Activities carried out with Belvedere thus permit to enhance students’ ability “to address scientific hypothesis testing in an organized and analytical way” (Suthers, Toth & Weiner, 1997, p. 6).

Social Interactions During Face-to-Face CCM Learning Activities

Roth & Roychoudhury (1992; 1993) are among the first researchers who addressed the issue of CCM in an educational context. Using qualitative research methods, they observed sustained science discourse during this activity in junior and senior physics classes who created paper-and-pencil concept maps in small groups. They noted that such discourse replicates typical interactions in scientific communities, that is, “co-construction interactions”, “adversarial interactions” and “formation of alliances”. However, they also observed that dialogues are often reduced to short sentences or even one-word utterances, which led them to wonder whether this may prevent the development of more complex concepts, as well as more elaborated arguments. Sizmur & Osborne (1997) analyzed the degree of elaborated exchanges between 9- to 11- year-old children creating paper-and pencil concept maps collaboratively in science classes. They observed “the phenomenon of children’s continuing each other’s contributions” during CCM, which allowed participants to make more scientifically valid propositions than when the exchanges were not elaborated. Nevertheless, they also noticed that many ideas introduced in the conversations were not retained by the group, perhaps since they generally had been verbalised with non elaborated utterances.

Van Boxtel, van der Linden, & Kanselaar (2000) observed a larger quantity of elaborated
cognitive conflicts and constructed reasoning episodes between pairs of children creating concept maps compared to those creating posters. However, in the Chang, Sung, & Lee (2003) study, adult participants are not as prone to negotiate their ideas and consensus is rare, although it should be mentioned that in that case, one member of each group of three or four was elaborating the map, while others were providing comments and suggestions.

Other studies conducted with adults show that social interactions during CCM were quite cognitively engaging. Based on observations of four triads of university students who co-elaborated concept maps during a semester, Steketee (2006) noted that “structural discourse” had a strong presence in each recorded session: “groups reflected on their combined prior knowledge, made inferences about it, challenged each other, determined the implications of interrelationships and made attempts to fit ideas into a coherent explanation” (p. 11). Ryve (2004) showed that communication among university students who created concept maps in triads in the domain of Linear Algebra contains the elements that are characteristic of a “mathematically productive interaction” (p. 157). This researcher found several examples of “explicit interpersonal elaborations of the intended foci” (p. 172) in the students’ discourse.

We found very few studies examining correlations between interactions during CCM and the quality of the maps produced by the group (e.g. Chung, O’Neil, & Herl, 1999; Sizmur & Osborne, 1997). In general, such studies conducted with children show that more interactions and more elaborated, high-level and complex interactions, lead to improved performance.

A single study exploring correlations between post-test learning measures and social interactions during CCM was found. This study was also conducted with children (Van Boxtel, van der Linden, & Kanselaar, 1997, 2000). Results show that the frequency of “elaborative episodes” during CCM correlates with comprehension measures.

This overview of research reveals that (1) most studies that investigate social interactions during face-to-face CCM in an educational context have been conducted with children and relatively few have involved adult participants; (2) such studies show that, in general, CM can trigger cognitively productive interactions; (3) the very few studies that investigate the effect of constraints imposed on activities of knowledge modeling tend to show that they have a positive effect on the quality of the external representation produced and on the interactive dynamics among learners, and (4) using an intersubjective perspective to observe both actions and communications between partners remains to be explored in CCM studies.

THE MAIN FOCUS OF THE CHAPTER

Our literature review in the field of CCM in education, as well as informal conversations with researchers, lead us to think that many investigators hesitate to restrict the “flexibility of expressiveness” (Alpert, 2004) of CM tools by imposing some kind of typologies of knowledge objects and/or of links, although, as we mentioned earlier, many of them self-contradictorily provide the learners with a list of concepts and/or links, which is an even more constraining modality.

Some authors argue that the “obligation of freedom” in link labelling is an essential condition to engage learners in active elaboration of knowledge relations and in more meaningful learning. This practice would help learners in the identification and progressive differentiation of domain-specific relations. Indeed, some studies show that learning increases link diversity: experts establish more links than novices, and the links of the former are more information-rich (Herl, 1996; Markham, Mintzes, & Jones, 1994). When creating maps, novices tend to use essentially the verbs “to be” and “to have” (Fisher, 1990), or “includes” and “are related” (Baroody & Bartels, 2000) as linking terms. In that sense, maps created
by experts are more domain-specific than those built by novices.

On the other hand, expert language and scientific language tend to be parsimonious. As stated by Kharatmal & Nagarjuna (2006), “though we may think that there can be innumerable number of linking words, if we look closely into any expert domain in any science, we realize that the number of kinds of linking words is limited, and does not increase as the knowledge advances”. These authors thus suggest some refinement to the Novakian CM technique in order to make it more effective for science education by inculcating some “discipline in choosing the right kind of relation types”. That explains why some researchers (e.g. Holley & Dansereau, 1984b) introduced a typology of links in their CM technique. Such position is similar to the one claimed by Medland (2007) who proposes that young children be trained in the use of ontologically- and epistemologically-based language to help them analyze, synthesize and share knowledge. The main idea is that if we want students to develop thoughts that meet the requirements of scientific reasoning, they should be provided with language that matches scientific thoughts, such as the ones used by expert scientists.

We propose a CM approach that, we think, offers an original compromise: Given that links are usually represented with verbs (which express actions) in concept maps, one may envision representing actions in nodes rather than in links. These nodes would then be a special kind of nodes, representing procedural knowledge (albeit in a declarative format). Such a solution makes it possible to preserve both the diversity and the specificity of knowledge from a given field. Moreover, the links are then used to represent only generic relations, resulting in a more economical and more parsimonious representational language. In addition, the expressiveness of the CM language is enhanced by making the domain-specific procedural knowledge more salient. In other words, the representation of “actions” into the nodes would help in focussing attention of the mapper not only on the meaning of concepts but also on the meaning of actions, given that the mapper is now able to work on linking these actions between them and on linking these same actions to concept nodes.

This solution was selected for MOT7, an object-typed CM software tool that integrates a typology of links and a typology of knowledge objects (nodes). We have been working with this tool for over a dozen years as a teacher and as a researcher. We used it as (1) an instructional design tool (Doré & Basque, 2002), (2) a learning tool proposed to students enrolled in online courses (Basque & Pudelko, 2002,, 2003), (3) a support tool to conceptualize theoretical constructs, either individually (Basque, 2004) or in groups (Basque, 2004; Basque et al., 2002; Basque, Rocheleau, Paquette, & Paquin, 1998), and (4) a tool to elicit expert knowledge and to transfer expertise in organizations (Basque, Imbeault, Pudelko, & Léonard, 2004; Basque, Paquette, Pudelko, & Léonard, in press). For us, such a wide experience with object-typed CM in various individual and collective activities convinced us of the potential of this tool for meaning-making and meaning-negotiation for our own purpose.

A few years ago, we launch a research program in the field designed to address, among others, the mediations of such a tool in collaborative learning situations where adults acted as participants. Our main research question was the following: does this object-typed CM tool favour or hinder the participants’ learning and meaning-making and meaning-negotiation processes?

Pudelko (2006) explored this question through a microgenetic study of epistemic mediations of this tool in an individual CM activity designed to enhance text comprehension. Data shows the transformations of the external and internal activity structures induced by the use of the tool. Based on this work, we examine, in this chapter, a CCM activity which also involves text comprehension and which was performed with MOT by one dyad...
Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping of adult learners working face-to-face. The data come from a larger study designed to compare three CCM conditions: a face-to-face setting and two distance conditions, one being synchronous and the other asynchronous (Basque & Pudelko, 2004).

In the remainder of this section, we will first describe the MOT software tool and its object-typed CM language. Then, the CCM situation under study and the data analysis methodology used for this case study are briefly presented. Finally, results are revealed through the presentation of a collection of vignettes taken from the data protocol.

### MOT: An Object-Typed Concept Mapping Tool

The MOT software tool has been developed at the LICEF Research Center by Paquette and his team (Paquette, 2002). This knowledge modeling tool includes three types of abstract knowledge objects (nodes) that are classified with different graphic shapes: concepts (rectangles), procedures (ovals) and principles (hexagons). MOT also differentiates concrete knowledge objects (KO), called facts (rectangle with indented corners), which refer to instances of abstract knowledge objects (see Table 1).

This classification of knowledge objects reaches a consensus in the educational literature, despite certain divergent opinions relative to terminology and associated definitions (e.g., Merrill 1994; Romizowski 1999; Tennyson and Rasch 1988; West, Farmer, and Wolff 1991).

To represent a certain type of knowledge object in a map, concept mappers must first select a type of knowledge object from a menu before they drag-and-drop a specific graphic shape assigned to such knowledge object in the MOT windows and adjust it to the desired size. They can then input the label they wish to append.

Knowledge objects are connected with each other through arrowed links. When links are selected from the menu and drawn between two knowledge objects, the first letter of the link label is automatically displayed on the link (see Figure 1). The link typology comprises six types of links: Composition, Regulation, Specialisation, Precedence, Input or Product (I/P) and Instance.

The representation of links must conform to “grammar rules” established in the software. For example, a “specialisation link” (S; equivalent to ‘sort of’) can only be used between two objects of the same type. Consequently, if the user relates two knowledge entities of different types with the S-link, the software will automatically display the default link, that is, the best-suited and the most

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### Table 1. The typology of knowledge objects (KO) in MOT

<table>
<thead>
<tr>
<th>Types of KO</th>
<th>Descriptions</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts</td>
<td>Class of objects from a given field (what?) which share common properties. Property ‘values’ are used to differentiate objects from one another.</td>
<td>• Square • Book • Vertebrate animal.</td>
</tr>
<tr>
<td>Procedures</td>
<td>Set of operations that permit actions on objects (how?).</td>
<td>• Multiply two-digit numbers. • Search information on the Internet. • Manage a project.</td>
</tr>
<tr>
<td>Principles</td>
<td>Statement to describe object properties, establish cause-effect links (why?) or determine in which conditions a procedure applies (when?). Principles often take the shape of “if Condition X, then Condition Y or Action Z”.</td>
<td>• When the soufflé is ready, it must be served immediately. • Road safety rules. • Metal dilatation laws pertaining to the effect of heat. • Instructional design principles.</td>
</tr>
<tr>
<td>Facts</td>
<td>• Instantiation of knowledge of the type concept, procedure or principle. When a fact instantiates a: o • a concept, it becomes an example. o • a procedure, it becomes a trace. o • a principle, it becomes a statement.</td>
<td>• Example: A specific book. o Trace: The procedure I used to manage a specific project. o Statement: If I heat my silver bracelet to a temperature superior to 200°F, it becomes longer.</td>
</tr>
</tbody>
</table>
probable according to the knowledge modeling grammar implemented in the software. If users disagree with the suggested link, a right-click on the link and choose another one from the pool of “permitted” links (the invalid links not being clickable). Table 2 provides a summary of valid links that can connect different types of knowledge objects according to the MOT grammar. This grammar can be viewed as a collection of representational “micro-structures” that guides the representational activity. It is based on a sort of “natural” and pragmatic semantic, which aims at enhancing coherence and reducing ambiguity in the knowledge models produced, which thus facilitates their interpretation (Paquette, 2002).

However, users can put their own label on an “untyped” (or undefined) link. A specific shape is also provided for “untyped” knowledge objects. The tool can thus be also used in accordance with an unconstrained concept mapping approach.

Figure 1 shows an example of a map in the domain of waste elimination. The map describes two main types (sort of) of procedures (incinerate and bury) to eliminate waste, which is also defined as a procedure. Concepts are defined as input to or output of (I/P) such procedures. Principles are linked to these procedures with the input/output and regulation links. No facts are represented in the map. The perspective adopted here to describe the domain is thus primarily procedural. Concepts

Table 2. Valid links between different types of knowledge objects according the MOT grammar

<table>
<thead>
<tr>
<th>Destination</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept</td>
<td>Concept</td>
</tr>
<tr>
<td>Procedure</td>
<td>I/P</td>
</tr>
<tr>
<td>Principle</td>
<td>R</td>
</tr>
<tr>
<td>Example</td>
<td></td>
</tr>
<tr>
<td>Trace</td>
<td></td>
</tr>
<tr>
<td>Statement</td>
<td></td>
</tr>
</tbody>
</table>
are used here to indicate the inputs and the outputs of the procedures represented, and principles are used to specify some conditions or constraints regulating these procedures.

Other types of knowledge structures, from simple to complex ones, can be represented with MOT. Paquette (2002) identifies thirteen different types of knowledge structures that can be represented, using the set of primitives of the MOT language, such as taxonomies or typologies of concepts, procedures, principles or facts (all links are of the specialisation type), component structures (part-whole; all links are of the composition type), flowcharts (including iterative procedures), laws and theories, decision trees, etc.

Among other functionalities of the MOT software tool, we find the possibility of creating sub-maps attached to each knowledge object represented in the higher-level map, as well as the feasibility to attach documents of different formats (with OLE or URL links) with each knowledge object. It is also possible to attach a “comment” to knowledge objects or links.

**The Collaborative Concept Mapping Situation**

As mentioned above, the issue discussed in this chapter is addressed with data taken from a larger research project conducted with dyads of volunteer adult participants who elaborated a concept map with the MOT tool, either in face-to-face or remote conditions. The analysis of the whole data collected is on-going. Here, we focus on the CCM activity of one of the eight dyads who worked in the face-to-face condition. This dyad obtained the best concept map score, as determined by an evaluation method based on a comparison with an “expert map”, although the learners’ score falls far beyond the maximum score. Our goal in choosing this dyad was to study how the MOT tool and language contributed or not to the relative success of this dyad in creating their map.

The experimental research methodology used to generate such data is detailed in Basque & Pudelko (Basque & Pudelko, 2004); only the gist of the investigation is reported here.

The experiment took place at the LORIT, a distance learning engineering research laboratory based at Tele-université, Canada. Participants volunteered to participate to this study by responding to an invitation sent to different discussion lists at this university. Only those corresponding to the following criteria have been retained: (1) they were postsecondary students or had post-secondary instruction; (2) they had no or low familiarity with MOT or with other graphical node-link representations; (3) they had no or low familiarity with the domain described in the texts used in the experimentation.

Three dyads participated in each experimental session, which proceeds as follows. First, participants completed a short comprehension pre-test. Second, they were trained on the MOT software and technique (75 minutes). Third, they practiced concept mapping by using MOT to create a map individually on the topic of waste elimination (20 minutes). Fourth, after a 15-minute break, participants were paired arbitrarily and asked to perform the CCM task. This task consisted of elaborating a concept map with MOT, representing the domain described in a one-page text. This text has been written by the first author as part of course material used in a distance education course in Cognitive Psychology. It describes the main components of the Human Information Processing System (Sensory Memory, Short-Term Memory and Long-Term Memory) and the Cognitive Information Process (CIP). After having read the text individually for 5 minutes, pairs were allotted 45 minutes to construct their CM using the MOT tool. They had access to a printed version of the text during the CCM activity. At the beginning of the session, one member of each pair was arbitrarily identified as the “editor” of the map (the one who manipulates the mouse), yet participants were told that they could freely change roles during the session. Finally, after a
second 20-minute break, participants filled out the post-test (identical to the pre-test).

Each dyad session was audio- and screen-captured with the Windows Media Encoder (WME) software and the dyad’s final map was collected.

Data Analysis Method

All dialogues of the chosen dyad were transcribed verbatim, and the verbatim protocol was cut up into episodes. Each episode represents an intentional act expressed explicitly either by the participants’ actions, by their utterances or both. Here are some examples of intentional acts: selecting a knowledge object (KO) from the text, indicating that a link should connect two specific KO (verbally only and/or by using the cursor). Some higher-level intentional acts imply a series of other intentional acts expressed altogether. For example, an utterance such as “Here, we should put a procedure called ‘select information’” expresses the intentional act of creating a KO, which includes a series of implied operations of identifying a KO from the text, labelling it and categorizing it. The intentional act can thus concern different levels of the activity (operations, actions, activity), as suggested in the Activity Theory (Leontiev, 1974).

Aside from identifying the intentional act expressed in each episode, the interactional style of the dyad is also analyzed concurrently, using an adapted version of Gilly’s coding scheme (Gilly, 1988), based on the socio-cognitive conflict theory (Doise & Mugny, 1984). To do so, the propositions expressed by participants in each episode are investigated in order to specify (1) if the proposition initiating the episode is explained or not, (2) the reaction of the partner, which can take the form of an implicit or explicit statement of agreement and disagreement, or no reaction at all, (3) whether statement of agreement and disagreement are explained or not by the partner. We also note disagreements expressed by the software tool, that is, when it does not display the link chosen by the learners.

Description of the Dyad's Meaning-Making and Meaning-Negotiation Process

Our analysis aims to illustrate meaning-making and meaning-negotiation actions and utterances which seem to have been induced by the constraints of MOT and its language during the session. After a brief presentation of the dyad under study in this chapter, we will first describe the actions and utterances related to the representation of each of the three main types of abstract KO (concepts, procedures, principles). Then, we will present how partners of the dyad acted and negotiated the representation of links.

Presentation of the Dyad

The dyad was composed of a woman of 24 years-old who teaches French as a Second Language and a male student of 21 years-old. They will be designated in this chapter by their gender: F (female) and M (male). Both of them declared having low prior knowledge in Cognitive Psychology before taking part in the experiment. Only M had used the MOT tool before the experiment, for a two-hour period.

At the beginning of the session, F was designated as the “editor” of the map, and the viewing of the WME file shows no indication that such a role changed over the session. This dyad used paper and pencil during a segment of the session, along with MOT. Participants lacked sufficient time to finish their map, even though throughout the session, they remained task-focused and produce scarce irrelevant utterances, most being short humorous statements.

The dyad’s final map includes five “submaps” (or sublevels), in addition to the first-level map. The whole map includes a total of 36 nodes, some of them being repeated in sub-maps.
Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping

Table 3. Vignette 1

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Subject</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>Okay, cognitive system. Hum… Would you agree that it is composed of three main memories?</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>Indeed, indeed.</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>Do you think it is split up into other elements than memory or only memory?</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>Hum… well… let’s say that we could split the cognitive system in three memories, and then… make another one… something that describes the information processing process.</td>
</tr>
</tbody>
</table>

Concepts

Actions of representation of concepts essentially consist of (1) identifying an object in the text and (2) deciding whether to represent them as concepts. Overall, 22 concepts appear in the map (including 6 concepts reused in sub-maps), which represents 61% of the total quantity of nodes. From the perspective of the MOT language, all of these concepts are valid, that is, they have been correctly defined as concepts. A comparison between concepts found in participants’ map and those in the “expert map” shows that participants added 5 supplementary concepts not found on the experts’ map and that 13 concepts defined by experts are absent in the dyad’s map.

Partners’ actions related to the representation of concepts triggered little discussions: they were performed without or with very few utterances. Hence, it seems that participants implicitly agreed on the categorisation of KO as concepts and on their labels, as shown in Vignette 1 (Table 3), an excerpt from the first two episodes that generated the resulting map shown in Figure 2. The suggestion of F to represent “cognitive system” and its three “memories” (SM, STM, LTM) in the map is accepted at once by M. Subject M responded to F’s question (“Do you think it is split up into other elements than memory or only memory?”) by saying that if there is something else to add here, such an entity would be the “information processing process”. As will be seen in Vignette 2, this last proposition will be re-enunciated and applied by F as soon as the three “memories” have been added as concepts in the map.

The distinction made in the MOT language between concepts and procedures seems cognitively productive for this dyad, as it allows participants to recognize, right from the start, the distinctive nature of a procedural representation (the information processing process) compared to a conceptual representation (the three memories), thus guiding the gist of the intentional acts that will follow. Indeed, the dyad will then begin to describe the information processing procedure and its sub-procedures, to which the three memory entities will be linked as inputs at certain points. This perspective is exactly the one adopted in

Figure 2. Map related to the Vignette 1
As we will see later, the procedural viewpoint adopted by the subjects all along the rest of the CCM activity also leads the participants to elaborate the following shared complex rules related to the creation of concepts: “A procedure has inputs and outputs” and “If a KO is the input of a procedure, then it is a concept”, which were expressed in the map by the representational micro-structure Concept $\rightarrow$ I/P $\rightarrow$ Procedure $\rightarrow$ I/P $\rightarrow$ Concept. These rules are not implemented as such in the software. Stemming from the basic properties of the MOT language, they have been inferred by participants. Each time a procedure was added to the map, the subjects were trying to specify the input and output concepts of this procedure. Compared to the representation of concepts, depicting procedures generated more discussion. Such dialogues generally started with a participant’s proposition (acted out or uttered) of the type “X is a procedure”, justified by the CM rule that states that actions or processes are represented as procedures (e.g., “X is a procedure since it is an action”). For example, as already mentioned, right from the start, M suggested representing the information processing process as a procedure. Note that although he stated that this procedure is linked in some way to the concept “cognitive system” (see Vignette 2 [Table 4]), neither participant specified the nature of such a link (see Figure 3), which remained unspecified until the end of the session.

All other procedures appearing in the final map
Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping

have been created following the inferred rule: “actions are represented as procedures composed of successive steps (or sub-procedures)” Participant M clearly asserted that when he said (Vignette 3, line 53) that it is necessary to “split up [the information processing procedure] into steps” and then “split up those steps over again”. When F agreed, M enumerated these steps (Vignette 3, line 55) and repeated such a comment in response to F’s objection (Vignette 4, line 60): “They’re still steps, which are processes, which are connected through Precedence links” (Vignette 4, line 61). Participant F concurred with such reasoning. In the remainder of the CCM activity, no other disagreements or questions surfaced when representing procedures, which amount to 12 in the final map, all of them correctly represented. (see Vignettes 3 and 4 [Table 5 & Table 6])

Principles

Actions related to the representation of principles have been scarce: only three principles have been represented in the final CM. Such a discovery is even noticed by participants themselves, who seemed to adhere to an implicit (and inaccurate) shared rule: “the map must include various types of knowledge”. Hence, on Line 338, more than 25 minutes after the session started, F worried that they “haven’t put in a single principle”. Participant M replied that they already had inserted “one or two”, which is actually a single one at that point.

It seems that actions related to the representation of principles were based essentially on two inferred representation rules which seemed equivalent to participants: “X regulates, then X is a principle” and “X is a principle, then X regulates”. For participants, a symmetrical implication seems to imply a Regulation link (R). In other words, principles require a Regulation link and, conversely, a Regulation link requires a principle. Note that the former solution is incorrect in the MOT language. Such a deduction probably stemmed from the short training provided to participants, which addressed only Regulation links between principles and other types of knowledge, whereas other links, such as Composition and Precedence, were not covered in relation with principles.

Participants’ limited interpretation of possible ways to illustrate relations between principles and other types of KOs created a major difficulty at the end of the session. Attempts were made to represent the idea that temporal constraints regulate the process of storage of information in Short-Term Memory, which is described in

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Subject</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>M</td>
<td>I think it should be split up, see, kind of into seven steps, and then, those seven steps should be split up over because here, also, I’m afraid it will be too loaded. You see what I mean?</td>
</tr>
<tr>
<td>54</td>
<td>F</td>
<td>Okay.</td>
</tr>
<tr>
<td>55</td>
<td>M</td>
<td>See, for example, the first one would be perceive, then, hum, recognize… select… hum store…. encode.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Subject</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>F</td>
<td>Hey, do you find that here, we just have to specify the seven steps, very schematically? Or if we have to represent them more in a quasi-linear fashion, huh!?</td>
</tr>
<tr>
<td>61</td>
<td>M</td>
<td>Well, hum, they’re still steps, which are processes… which are connected through Precedence links.</td>
</tr>
</tbody>
</table>
the selected information is stored in the Short-Term Memory (or Working Memory) for a few seconds; it can be stored longer if certain cognitive strategies are used”. Although participants spent the last twelve minutes of the session attempting to solve this challenge, they failed to represent their comprehension of this idea in a satisfactory way. We think that this is partly due to the fact that they were not sufficiently aware of other possible relations that can be established between principles and other types of KOs. Furthermore, we observe that they self-imposed an additional constraint in the CM method, which complicated their meaning-making effort: they labelled nodes with the fewest words possible. Indeed, if this implicit rule generally applies to concepts and procedures, it is ill-suited for principles, as they are often formulated with short sentences, of the type “If…then”. For example, in the “expert map”, temporal constraints linked to the process “Store in Short-Term Memory” are translated through two principles linked to that process with a Regulation link and formulated as such: “A few seconds” and “If cognitive strategies are used, stored longer”. Thus, it would seem necessary that CM trainers emphasize explicitly that principles can be labelled with more than one word, if need be. This would prevent participants from over-dissecting principles beyond the point where integrity and meaning is lost, as was the case in this dyad. Indeed, as shown in Figure 4, in their attempt to illustrate the sentence mentioned above, the dyad added a proliferation of KOs in trying to specify the principle “time constraint”, which leads M to generate convoluted propositions which F can hardly understand (i.e., “Here, I’d say that we could add a small ‘Zero Plus’ meter, so your time constraints, then they count, plus the temporal bonus…”). Such dialogues, seemingly based on a misinterpretation of the MOT constraints, would have hindered the construction of shared meaning.

We also found that participants’ actions and utterances regarding the representation of principles are based on another MOT rule they were taught: principles can represent “constraints” or “conditions”, such as time and space, which regulate other KOs (see Vignette 5 [Table 7] and Figure 5).

However, participants disagreed on the level of importance of this rule, which, as we will see, lead them to discuss, later on (see Vignette 9),
whether “sensory memory” falls into the category principle or concept. For F, who perceives sensory memory as a “space” where information “storage” occurs, it should appear as a principle (which is not necessarily a valid inference in the MOT language). However, for M, who ended up convincing F, the sensory memory (as all sensory receptors, the STM and LTM) does not consider it a “space” but rather an “instrument” for storing processes and should consequently be presented as a concept (according to a rule presented at the training session, where inputs to procedures constitute concepts). Hence, in this case, the representational properties of the MOT language lead participants to identify and discuss in detail issues for representing structural components of the cognitive system as a “space” or a “location” where information “travels” (according to the typical metaphor found in cognitive psychology scientific literature) or as active “registers” that are defined as functions of the human cognitive system.

Table 7. Vignette 5

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Subject</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>F</td>
<td>“In the environment”… do you think it’s a regulation?</td>
</tr>
<tr>
<td>106</td>
<td>M</td>
<td>Well, hum, gess so, no? Well, comes from the environment. Well, it’s a space unit, right…</td>
</tr>
<tr>
<td>107</td>
<td>F</td>
<td>Yes, it’s a space unit. Okay. Yes.</td>
</tr>
<tr>
<td>108</td>
<td>M</td>
<td>That’s another thing we must indicate.</td>
</tr>
<tr>
<td>109</td>
<td>F</td>
<td>Okay.</td>
</tr>
</tbody>
</table>

Links

Links Between Knowledge Objects of the Same Type

Links between KOs of the same type are of three types: composition (part-whole), class inclusions (sort of) and chains (temporal precedence). The third micro-structure can only be used between procedures, while the other two apply to all types of knowledge.

Participants discussed the composition micro-structure between concepts few times during the CCM activity. One occurred when identifying the link between the concepts “cognitive system” and the “three memories”, where the dialogue triggered by F’s initial proposition to use a composition link (see Vignette 1) is very brief and mutual agreement is quickly established. Moreover, the action was immediately applied, along with F’s utterance: “Okay, so this is decomposed, right? So we’ll add [C] links on it”.

A second instance where the composition micro-structure is used by participants occurred when time comes to illustrate M’s perception that

Figure 5. Map related to the Vignette 5
the Short-Term Memory is composed of information “that makes it possible to attribute meaning to the sensory trace” (see Vignette 6 [Table 8]).

Hence, this composition link allowed M to elaborate the idea that long-term memory does not directly provide meaning to the sensory trace but rather, the information it contains, hence the information stored in it (see Figure 6).

As to composition links between procedures, we observed that they are not represented in the map through the Composition (C) link, but rather through sub-maps. As mentioned above, at the onset of the activity, M proposes “splitting” the “cognitive processing” method into main steps (perceive, recognize, select, store), before conducting additional decompositions of each of these procedures into sub-procedures. He also proposed representing each of these actions by “decomposing” them into sub-maps in order not to “overload” the first-level map. His partner accepted such a strategy. This approach is actually accurate and often useful when the first-level is replete with a large number of knowledge units. However, it seems that, in that case, it prevented the participants from seeing certain relations between the “steps”, such as the presence of “inputs” and “products” between the steps of superior levels.

It is interesting to note that participants specified, in a sub-map decomposing the “information processing process” (defined as a procedure in the first-level map), a relation of temporal precedence between the various processes that pertain to this procedure (see Figure 7). This was done before decomposing successively each of them. It seems that the participants viewed the Precedence link as an intrinsic element of the “decomposition” link.
rule. In other words, they adopted the following reasoning: “if an action is decomposed in steps, then such steps follow one another in a temporal manner”. Although this inference is usually valid, it can sometimes prevent the participants from seeing that certain actions can be simultaneous. However, in the CCM activity of this dyad, such a shared interpretation allowed them to quickly and exhaustively identify and represent the different information processing phases described in the text.

**Links Between Knowledge Objects of Different Types**

As mentioned above, most concepts have been created by subjects through the application of a micro-structure rule that is used to illustrate relations between (1) an input represented as a concept connected to a procedure through an I/P link and (2) a product or output also represented as a concept connected with a procedure through an I/P link (going from the procedure to the concept).

When the two links (input and product) are connected to the procedure, they express a “transformation” process, which is an essential micro-structure to comprehend a processing system (a functional system). We noted that this micro-structure rule has been progressively elaborated and implemented by the dyad during the CCM activity. Participant M is the initial bearer of this idea. Looking at the map reproduced in Figure 7, he declared: “there is something intriguing here ... there are links between these processes. Kinda like... you have processes that generate products”. This proposition, which revealed a certain “cognitive discomfort” in M, is at that time ignored by F. However, M did not abandon such an idea and brought it up again once they agreed on the set of steps for information processing. This time, however, his partner considered the issue and formulated questions in trying to grasp the meaning of M’s proposition and inviting him to be more specific, which M was not able to do then (see Vignette 7 [Table 9]).

Then, the dyad will be engaged repeatedly in an active joint elaboration around this rule of “transformation of an input into an output” in the following episodes. For example, when elaborating the sub-map of the “perception” procedure (see the resulting map in Figure 8), F proposed that the sub-procedure “capture” process “takes stimuli and takes sensory receptors” (line 103), while M indicated that “capture produces something, but we don’t know its name” (line 110), and that such a unit is both a product of the “capture” procedure and an “input” of the following procedure, that is,

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**Figure 7. Submap of the “information processing” procedure**

![Submap of the “information processing” procedure](image)

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**Table 9. Vignette 7**

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Subject</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>86</td>
<td>M</td>
<td>Hum, indeed, these steps, they each produce, in fact, each time they produce something that is the common denominator of the following step, it seems.</td>
</tr>
<tr>
<td>87</td>
<td>F</td>
<td>The common denominator and what? Pardon?</td>
</tr>
<tr>
<td>88</td>
<td>M</td>
<td>At the following step. See, for example, the stimulus, it produces... wait, it produces... ah, never mind, it doesn’t produce anything.</td>
</tr>
</tbody>
</table>
the procedure labelled “storing” (line 112). While discussing this issue, each partner completed the action or utterance of the other (see Vignette 8 [Table 10]).

In the map presented in Figure 8, however, the two “inputs” linked to the “capture” procedure (“stimulus” and “sensory receptors”) do not play the same role: the “stimulus” constitutes the object of the “capture” process, while the “sensory receptors” is the instrument that makes such processing possible. Such a distinction is not clear to F, as shown in the Vignette 9 (Table 11).

Later, M reapplied these two same inferred rule (“procedures transform an input into a product” and “there may be two types of inputs”) when the dyad specified the procedure “attribute meaning to stimulus”, which, again, required explanations, as F continued to express doubts (see Figure 6). In the end, the first of these rules had become a main constraint guiding the structuring of the map, which makes the dyad asking systematically: “what is the input of this procedure?” and “what is the product of this procedure?”.

Finally, the participants’ reasoning regarding the actions of linking the knowledge objects seems to have been partly influenced by the fact that they sought to respect an explicit instruction they were given: avoid the use of “untyped links” as much as possible. For example, when discussing the following sentence of the text “the selected information is stored in the short term memory for a few seconds; it can remain longer if the participants use certain strategies” (see Section 3.3.3 and Figure 4), M proposed to split

---

**Table 10. Vignette 8**

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Subject</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>162</td>
<td>F</td>
<td>Yes, okay. And then we said that… inputs.</td>
</tr>
<tr>
<td>163</td>
<td>M</td>
<td>Inputs are stimuli and the others….</td>
</tr>
<tr>
<td>164</td>
<td>F</td>
<td>Which are concepts.</td>
</tr>
<tr>
<td>165</td>
<td>M</td>
<td>There! Exactly.</td>
</tr>
<tr>
<td>166</td>
<td>F</td>
<td>How is the first one called? Stimulus?</td>
</tr>
<tr>
<td>167</td>
<td>M</td>
<td>Stimulus or stimuli.</td>
</tr>
<tr>
<td>168</td>
<td>F</td>
<td>Stimulus, hum, and the other is…?</td>
</tr>
<tr>
<td>169</td>
<td>M</td>
<td>Sensory receptors.</td>
</tr>
<tr>
<td>170</td>
<td>F</td>
<td>Okay. So these ones, they were hum… inputs.</td>
</tr>
<tr>
<td>171</td>
<td>M</td>
<td>Inputs-outputs, yes.</td>
</tr>
<tr>
<td>172</td>
<td>F</td>
<td>So the relation goes that way.</td>
</tr>
<tr>
<td>173</td>
<td>M</td>
<td>And the other this way.</td>
</tr>
</tbody>
</table>
Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping

Table 11. Vignette 9

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Subject</th>
<th>Utterance</th>
</tr>
</thead>
<tbody>
<tr>
<td>208</td>
<td>F</td>
<td>Well, I don't get it. Explain the link between this and that.</td>
</tr>
<tr>
<td>209</td>
<td>M</td>
<td>Here, you have two components arriving. Here, you have an information, hum a captured stimulus. So there! And you store it into the sensory memory.</td>
</tr>
<tr>
<td>210</td>
<td>F</td>
<td>Yes.</td>
</tr>
<tr>
<td>211</td>
<td>M</td>
<td>The sensory memory is the storage instrument for the captured stimulus.</td>
</tr>
<tr>
<td>212</td>
<td>F</td>
<td>Okay.</td>
</tr>
<tr>
<td>213</td>
<td>M</td>
<td>So, see, they are two inputs.</td>
</tr>
<tr>
<td>214</td>
<td>F</td>
<td>Okay.</td>
</tr>
<tr>
<td>215</td>
<td>M</td>
<td>Because we took both the stimulus input and the sensory receptors…</td>
</tr>
<tr>
<td>216</td>
<td>F</td>
<td>Yes, yes, right, okay, I get it...</td>
</tr>
</tbody>
</table>

the “Time” principle (which was then already represented in the map and which later became “Time constraint”) into two units in order to be able to “represent it with a composition [link] rather than an untyped link”.

When attempting to express this temporal constraint which included two conditions (“if no use of cognitive strategies, then duration lasts a few seconds” and “if use of strategies, then lasts longer”), the participants tried firstly to add specialisation links between the “Time” principle and the “Short” and “Long” concepts, which is not allowed by the software. Thus, just a few minutes before the session is over, MOT got involved for the first time as an “active arguer” into the conversation, causing a three-way dialogue. When MOT refused to accept the specialisation link that the participants tried to add between the “Short” concept and the “Time” principle, M realized that “the problem is that apparently, we cannot put just about anything here. It doesn’t want us to do the the... the software prevents us from putting the the...” This caused the introduction of a new concept labelled “Duration” so that the “Short” and “Long” concepts could be connected to it through specialisation links. The label of the principle “Time” was then changed for “Time constraint”, which was linked to the “Duration” concept through a regulation link (see Figure 4).

Such a compromise, the product of a three-way negotiation, conforms to the constraints of the MOT language. However, it still did not satisfy the participants, whose intentional act expresses an alternative for two conditions (whether strategies are used or not). They then pursued their meaning-making effort, adding numerous KOs: two procedures (“Increase duration” and “Use strategies”) as well as two concepts (“Subject” and “Strategies”), which they failed to link due to the session time limit.

All the discussion around the representation of the principle “Time constraint” illustrates how the software (which applies the object-typed grammar rules) can become an active participant, joining the dyad in their meaning-making and meaning-negotiation efforts throughout the CCM activity. The interpretation given by the participants to the representational properties of the CM language and to the CM method also guides strongly the activity, usually in a productive way but not always.

CONCLUSION

Our qualitative analysis of joint actions and utterances by a dyad of adult participants involved in a CCM activity designed to enhance text com-
Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping

prehension and mediated with an object-typed CM tool, shows that co-learners are actively involved in intense meaning-making and meaning-negotiation processes. The text, an excerpt from typical instructional material in the field of Cognitive Psychology, includes numerous propositions which are more or less salient or easily grasped than they initially appear. In this sense, this may consist of the main advantage of CCM activities for text comprehension: they provide an opportunity to work collaboratively on the meaning of words and propositions in order to co-construct shared meaning.

In such a space of shared external representation, questions asked, arguments stated and rules inferred are strongly biased by the representational properties of the CM software tool and language, as well as by the CM technique proposed to learners. In this particular investigation, where a CM tool integrates category constraints for both nodes and links, as well as a grammar that determines valid links between different types of nodes, it is clear that the participants used such constraints to guide their meaning-making and meaning-negotiation actions.

The users’ interpretation of representational properties of the selected CM tool and language is based on an active construction of meaning, the stabilisation of which depends on both the software and the participants’ agreement. A preliminary analysis of the dyad’s interactional style reveals that instances of disagreement were infrequent in that dyad, who adopted instead an interaction mode that Gilly (1988) calls “co-construction”, where A initiates an action or utters a proposition, which is accepted by B, who performs the action or further refines A’s initial proposition. Almost four times less disagreement occurs in this dyad. The software also rarely disagreed with the dyad, thus participating in setting up an interaction mode of the “co-construction” type with the participants. Furthermore, disagreements were discussed, as it was also the case for over half of the instances where participants agreed.

Representational properties of an object-typed concept mapping tool language and method can have an authentic epistemic dimension. Most of the time, it seems that they helped learners building knowledge which is valid from a scientific perspective, and, to a certain extent independent from the field. For example, the micro-structure “transform an object with a tool” built by the participants, expresses knowledge and relational structures which characterize various knowledge domains such as functional systems in biology, ecology, mechanics, etc.

This being said, it should be noted that the goal of the CM activity proposed to learners must be considered when addressing the issue of selecting a constrained or an unconstrained concept mapping language in educational contexts. When the main goal is to allow teachers or researchers to track misconceptions in students’ cognitive structures, it may be best to constrain the CM activity the least possible and eventually use computerized “disambiguation” tools to analyze and assess maps (da Costa, da Rocha, & Faveo, 2004). However, it seems to us that this practice is not optimal for the learners’ active participation in joint and dynamic processes designed to structure and negotiate knowledge. On the contrary, in this case, the tool becomes an epistemic representational guide for co-learners. To this end, we hypothesized and hopefully demonstrated that a more disciplined language of concept mapping, such as an object-typed one, would be a promising avenue.

**FUTURE TRENDS**

Obviously, our conclusion, based on an analysis of a single case, must be validated and further investigated in future studies. We believe this issue contains much research potential in the field of CCM, and that intersubjective epistemology is a rich framework to help in shedding some light on the meaning-making and meaning-negotiation processes of concept mapping groups.
To better grasp the contribution of concept-mapping tools, languages and methods in collaborative learning situations, and in order to verify how more or less constrained concept mapping approaches can support or hinder knowledge co-construction, more research is needed. Here are some research issues that we find particularly relevant for future investigations in the field:

- How do learners who produce less well structured maps use the representational properties of the CM tool?
- Do the processes of meaning-making and meaning-negotiation, as well as learning results, differ when learners use an object-typed versus an untyped concept mapping tool?
- What are the correlations between the dyads’ interactive and argumentation styles and (1) the quality of the map produced and (2) learning results?
- How should participants be trained to object-typed concept mapping in order to optimize the potential learning benefits?

**REFERENCES**


Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping


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**ENDNOTES**

1 Various terminologies have been used to designate more or less similar graphical knowledge representations (*knowledge maps, semantic networks, mind maps, knowledge graphs, cognitive maps, visual thinking networks*, etc.). Some characteristics of graphical representations are occasionally used to differentiate them (hierarchical or non-hierarchical map structures, labelled links or not, use of a link typology or not, etc.). The terminology has yet to be standardized. In this chapter, the expression “concept map” is employed, as it is most commonly found in educational science literature. However, it is used in a very generic sense to designate all graphical knowledge representations based on nodes and links.

2 Some of these studies compared face-to-face and distant conditions.

3 Created by Alberto Cañas’ team, Institute for Human and Machine Cognition, University of West Florida (USA): http://cmap.ihmc.us/
Intersubjective Meaning-Making in Dyads using Object-Typed Concept Mapping

4 Created by Kathleen Fisher & John Falletti’s team, SemNet Research Group (San Diego, USA): http://trumpet.sdsu.edu/SemNet_About_SemNet.html

The term “network map” used by Dansereau and colleagues at that time has been replaced later by “knowledge map” (O’Donnell, Dansereau, & Hall, 2002).

5 When juxtaposed to the term “knowledge”, the adjective “declarative” comprises two different meanings which are often misinterpreted. First, all overtly “verbalised” knowledge (i.e., expressed with words) is said to have a declarative format. Moreover, “declarative knowledge” can refer to knowledge pertaining to objects and object properties (the know-what), as opposed to “procedural knowledge” or knowledge pertaining to actions (the know-how). Procedural knowledge can thus be represented in a declarative format.

6 MOT stands, in French, for “Modélisation par Objets Typés”, which means “Object-typed modeling”.

7 Based at Télé-université in Quebec, Canada, the LICEF Research Center is a laboratory dedicated to cognitive informatics and training environments. For further details on MOT and to download an English version of the software freely, visit the LICEF Website at http://www.licef.ca.

8 The dyad obtained a “Knowledge Object Score” (KO Score) of 34/82 and a “proposition score” (P Score) of 50/192, for a total of 84/260. These results show that the quality of the maps created by all participants was quite low (KO Score: M = 25,65; SD = 6,16; P Score: M = 26,50; SD = 10,04), as measured by comparing them with an expert map created consensually by two MOT experts and two content experts (also knowledgeable in knowledge modeling with MOT). See Basque & Pudelko (2004) for more details on the scoring method and on group results.

9 LORIT is a French acronym that stands for “Laboratoire Observatoire de Recherche sur l’Ingénierie du Télé-apprentissage”, basically, a laboratory and an observatory for research pertaining to telelearning engineering. Télé-université is a distance education university. For more information about the LORIT, please visit http://www.licef.teluq.uquebec.ca/lorit/eng/index.htm.

10 Participants have not been introduced to concrete knowledge objects (facts) in this study.

11 Vignettes and maps have been translated from French.

12 In French, the term “information” can have a plural or a singular form. In figure 6 reproducing a part of the dyad’s map, the term “information” appearing at the left side has the plural form and the one appearing at the right side has the singular form.

13 This could be due to the fact that the participants were not introduced to the MOT feature that allows to “copy with a reference” a KO that comes from another level of the map. This feature facilitates finding KOs which are replicated in sub-maps. Moreover, when a modification is made to the label of a referenced KO, it will be done in all sub-maps where the KO appears.