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FREEDOM VS. RESTRICTION OF CONTENT AND STRUCTURE DURING CONCEPT MAPPING - POSSIBILITIES AND LIMITATIONS FOR CONSTRUCTION AND ASSESSMENT

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Abstract. Concept maps consist of both content and structure. When working with concept maps, educators give instructions for the students to follow while working on concept mapping. These instructions are usually provided in terms of *conditions* on the structure and the content of the maps. While educators have expectations in terms of the result of the concept mapping activity, often they are not aware of how the *conditions* on content and structure that are given to the students often has strong effects on the type and quality of concept maps the students construct. In this paper we analyze how different *conditions* affect the concept maps constructed and discuss how educators must be aware of these possibilities and limitations when working with students and in particular during the assessment of their concept maps.

1 Introduction

Concept mapping has been shown to be an effective tool in facilitating learning (Novak & Gowin, 1984) particularly when integrated with software such as CmapTools (Cañas et al., 2004) to create a concept map-centered learning environment (Cañas & Novak, 2005; Novak & Cañas, 2004). The applications of concept mapping in education are diverse, and encompass all domains of knowledge and students of all ages (Novak & Cañas, 2010). Concept maps are used extensively as an assessment tool, and the literature is abundant with studies on the use of concept maps for assessment and on the assessment of concept maps themselves (e.g., Besterfield-Sacre et al., 2004; Daley, 1996; Fischler et al., 2002; Mcgaghie et al., 2000; Reiska, 2005; Rice et al., 1998; Schmidt, 2006; Strautmane, 2012; Turns et al., 2000; Walker & King, 2003; West et al., 2000). There are also studies that compare the use of other graphic representations, such as tree diagrams (Yin et al., 2008) and other tools for representing the structure of knowledge (Jonassen et al., 1993). However, we shall deal only with so-called Novakian concept maps.

The widespread use of concept maps is based on the notion that a concept map is a reflection of the builder's cognitive structure and thus portrays his or her understanding of the domain depicted in the map. For example, a concept map built by a student will show misconceptions as wells as concepts that are not clearly understood, and at the same time it makes evident what the student does understand.

We consider that using concept maps only for assessment is a narrow application of the tool, given the increased learning that can be attained, for example, through the negotiation of meanings that takes place during the collaborative construction of concept maps by groups of students or in the increased understanding developed through an iterative process of researching a topic and including the newly learned concepts in a companion concept map that is itself part of a concept map portfolio (Cañas & Novak, 2005). However, independent of the way we use the concept maps with our students, at some point we most likely have to analyze the quality of students' concept map(s). What the concept map "tells us" is always part of the educational activity. Nonetheless, our experience and the literature (references will be presented later) suggest that the conditions of structure and content under which a concept map is built affect the quality and type of map that students construct. If as educators we are relying on "what the concept map tells us" as part of the educational activity --whether the assessment is direct or indirect-- we need to be keenly aware of the impact that different specifications for the construction of the maps have on the resulting maps. We believe that most educators are not aware and inadvertently use different conditions when working with concept maps with their students. In this paper we provide an overview of how some variations in specifications for the content and structure can lead to very different concept maps.

2 Background: Seeking Complementarity between Assessment and Learning

One of the early efforts to show relationships between learning and assessment was Bloom's *Taxonomy of Educational Objectives: the Classification of Educational Goals* (Bloom, 1956). The taxonomy identified 6 kinds of test items that required progressively higher cognitive demands from the learner. Bloom and his colleagues also identified the affective domain dealing with feelings and psychomotor domain dealing with actions, but the latter two domains never attracted the attention garnered by the cognitive domain. Level one (1) of Blooms taxonomy were items that dealt with the recall of specific information, and because this is the easiest to test for using true-false or multiple choice questions, study after study has shown that these are the most common type of item used, resulting in learners focusing primarily on memorization of information. Other levels of Bloom's taxonomy were (2) comprehension, (3) application, (4) analysis, (5) synthesis, and (6) evaluation. The challenge for educators has been to design instruction that encouraged or enhanced student's "higher order thinking". The problem over the years has been that so much of school instruction emphasizes rote learning of information with the result that students perform poorly on test items that require much more than rote recall of information. Since test items with near chance passing rates have little discriminating power, test makers usually discard these. Novak (2010) refers to this as the *psychometric trap*, which leads to the usual "objective tests" that assess little more than information recall. Thus such testing results in rote learning patterns in students with all the attendant limiting consequences.

Bloom's 1956 *Taxonomy* was rooted in the behavioral psychology that dominated Western education for decades. There was little in this psychology that could lead to improved school instructional practices. As the psychology of learning moved toward cognitive learning ideas in the 1980's, there also emerged new instructional ideas, and with these an increasing recognition that assessment needed to be improved to encourage *higher order thinking* and instructional practices that required more than recall of information. Among the instructional practices encouraged were more inquiry practices, especially in science and mathematics, student project work, often with student teams of 2-4 students, and other more creative instructional strategies. These emerging practices were recognized in a revision of Bloom's taxonomy published in 2001 (Anderson & Krathwohl, 2001).

From the perspective of our concept mapping community, the most significant advance in instructional practices and assessment of learning arose with the invention of concept mapping in the early 1970's. When students use concept maps to help organize the knowledge they are learning, there is enhanced opportunity for higher levels of meaningful learning (also referred to as *deep* learning) with all the cognitive and affective benefits that derive from such learning. Moreover, when concept maps are used to facilitate learning, they can also be used as an assessment tool capable of assessing not only recall of information but also those higher order skills that are described in Bloom taxonomies. Even more important, the use of concept maps for learning and assessment can help students "learn how to learn" for real understanding (Novak, 2010; Novak & Gowin, 1984).

3 Graphical Structure vs. Content

A concept map consists of a graphical representation of a set of concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts. The two concepts with the linking phrases that join them form propositions. Propositions are statements about some object or event in the universe, either naturally occurring or constructed. Propositions contain two or more concepts connected using linking words or phrases to form a meaningful statement. Sometimes these are called semantic units, or units of meaning (Novak & Cañas, 2008). Concept maps therefore consist of "graphical structure" and "content". We examine each of these separately.

3.1 Concept Map's Graphical Structure

The graphical nature of concept maps permits a topological or structural analysis of the map. The hierarchical structure of knowledge in a particular domain usually leads to a hierarchical structure in concept maps, with more general concepts at the top and more specific concepts at the bottom. A well-organized cognitive structure is necessary for meaningful learning, and usually leads to graphically well-organized concept maps. We do need to clarify that the hierarchical structure may lead to other representations, such as a cyclic concept map (Safayeni et al., 2005). That is, a conceptual hierarchy of concepts does not necessarily lead to a hierarchical structure of the map. Another important characteristic of concept maps is the inclusion of *cross-links*. These are relationships or links between concepts in different segments or domains of the concept map. Cross-links help us see how a concept in one domain of knowledge represented on the map is related to a concept in another domain shown on the map. In the creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer. There are two features of concept maps that are important in the facilitation of creative thinking: the hierarchical structure that is represented in a good map and the ability to search for and characterize new cross-links.

The graphical structure of concept maps provides the possibility of an objective *evaluation* of the concept map, and given the importance of a “well organized map” and the presence of cross-links, we fall into the trap of believing that the structural components provide a valid complete assessment of the concept map. By counting structural characteristics such as the number of hierarchical levels, the number of crosslinks, the number of propositions, etc., many rubrics have been developed that *assess* a concept map based on its structure, often as part of a more comprehensive rubric. Strautmane (2012) provides a comprehensive list of structural measures reported in the literature. In some particular cases, a structural-only appraisal can provide useful information, such as the topological taxonomy (Cañas et al., 2006) designed to evaluate the increase in complexity of a large number of concept maps in a nationwide project (Tarté, 2006) and that has also been used in automated software processes (Cañas et al., 2010; Navas & Chacón-Rivas, 2012; Valerio et al., 2008). Graphical information is of course pertinent in the assessment of the overall goodness of a concept map, for example the presence (or absence) of crosslinks that is indicative of a deeper understanding of the domain. The overall structure of the concept map provides an idea of the global organization of the map, showing for example clusters of concepts in subdomains, whether the concept map is ‘balanced’ or whether one subdomain includes a much large number of concepts and links than other subdomains. Concept mappers tend to ‘agree’ on what a ‘well structured concept map’ is, to the point that experts tend to agree whether a concept map is “good” by just looking at its structure without considering its content (Carvajal et al., 2006).

3.2 Concept Map’s Content

Every concept map should respond to a *focus question* that provides the reference or context for the map. The main question that we ask ourselves when *assessing* a concept map is, “Does it respond the *focus question*?” A good map will explain the response to its *focus question* in a clear fashion. The concept map’s content can be analyzed in several ways. The list of concepts can be analyzed for completeness (are any key concepts missing?), quality, and relevance with respect to the *focus question.* That is, the map could include a large number of concepts that are completely irrelevant to the *focus question* or topic of study. Similarly, each proposition can be evaluated for quality, completeness and relevance with respect to the *focus question*. Note the importance of evaluating the relevance of each proposition to the topic of study. There are rubrics in the literature that evaluate whether the proposition is ‘true’ or ‘false’, independent of the relevance to the topic of the concept map (Reiska, 2005). More in depth content analysis can examine clusters of concepts and relations between the concept within one cluster and also relations between the concepts from different clusters.

3.3 Graphical Structure and Content

Educators with experience using concept mapping with their students understand that both the graphical structure and the content, as well as the ‘interaction’ between the two need to be analyzed when determining “what does the concept map tell us?” about the student’s understanding of the topic. By interaction we mean how the structure and content together integrate for a better expression of the student’s knowledge. However, even when using the best rubrics that include both content and graphical structure, the educator needs to understand that the type and quality of the concept map may be more a reflection of the process and conditions under which the concept map was constructed than of the student’s understanding of the domain.

4 Construction of Concept Maps: Freedom and Restriction of Structure vs. Content

When asked to construct a concept map, students are provided with instructions that include conditions (or a complete lack of conditions) for the process. These conditions are part of what Ruiz-Primo & Shavelson (1996) refer to as the task demands and task constraints: what the student has to do to complete the task and limitations that the student has to follow while solving the task. These pre-given conditions or specifications are usually provided in terms of structure and/or content. For both structure and content, the specification can cover a broad range of values, from complete freedom of structure and/or content to restricted structure and/or content. By freedom of content we refer to the liberty that the map builder has to determine the topic, the *focus question*, the concepts, etc. of the concept map. By freedom of structure we consider the liberty the map builder has to decide the graphical structure of the map.

Figure 1 shows a variety of conditions that combine different degrees of freedom for structure and content that can be set for the construction of a concept map. The x-axis corresponds to the freedom of structure, and the y-axis to the freedom of content. The maximum freedom of content and structure corresponds to asking that a concept map be built about any topic the user wants with no restrictions (upper right corner of the graph), while asking the student to memorize a concept map (possibly constructed by the teacher) corresponds to a complete lack of freedom of structure and freedom (lower left corner of the graph). In the graph we've placed examples of conditions that are commonly used in educational settings. We clarify that the placement of the conditions on the graph is completely subjective and is not the result of any type of formal evaluation, and that the graph is useful to show the relative position of the conditions and is not meant to represent any absolute positions. In fact, the "process" under which the map is constructed affects the location of each of these in the graph. Additionally, there are other conditions that could be added to the graph; we did not intend to provide an exhaustive list. The reader should therefore consider the graph as an example of how different conditions that are established in the instructions to construct concept maps lead to variations in the freedom of structure and content. We proceed to analyze examples of how different combinations of freedom of structure and content can result in variations of the type and quality of the resulting concept maps. We are not concerned in this paper with the scoring criteria that could be used for the different *conditions.* Strautmane (2012) provides an overview of different scoring criteria for common concept mapping tasks.

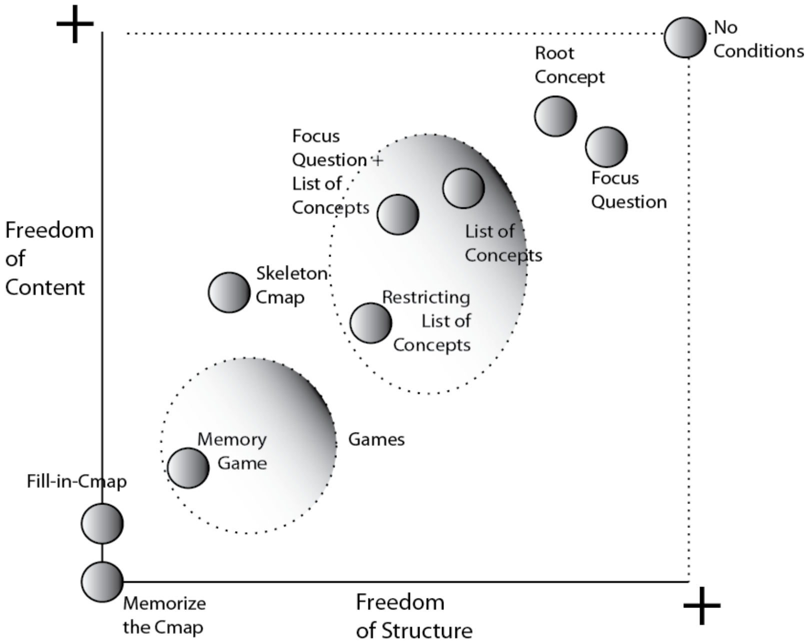

Figure 1. Freedom of Structure and Freedom of Content conditions during concept mapping.

4.1 No Conditions

Under *no conditions* the user is given the liberty to decide the topic of the concept map, and is not given a *focus question* or any other set of directions. This situation is typical of workshops for beginners where users from different disciplines build maps on topics of their personal interest. The lack of a well-formed *focus question* usually leads to a descriptive concept map instead of an explanatory map. As has been experienced by educators and workshop instructors, when faced with a blank canvas users are often intimidated and have difficulty constructing a concept map.

4.2 Focus Question

By providing a *focus question*, we restrict the student in both content and structure. Although one might think that the focus question only restricts the content, i.e. the topic, of the concept map, research has shown that the *focus question* may determine not only the content of the map, but also the structure of the map, and may lead to the construction of more explanatory maps (Derbentseva et al., 2006a) and cyclic concept maps (Safayeni et al., 2005). As educators we don't spend enough time preparing the *focus questions* that we provide our students. Our experience shows us that a good *focus question* is one of the conditions that can have a positive effect on the quality of the resulting concept maps, and the research mentioned above confirms it: we have found that the more open and dynamic the focus question, the more dynamic the propositions in the constructed concept map (Miller & Cañas, 2008a). This is probably one of the least used conditions that can have a substantial impact on the type and quality of the resulting concept map (we have discussed the *focus question* in detail in Cañas and Novak (2006)). For example, the focus question: "What is the structure of the circulatory system" will result in very different concept maps than those addressing the question: "How does the circulatory system provide oxygen to all body cells?" The latter question is more likely to indicate a deeper understanding.

4.3 Root Concept

Providing the student the *root concept* of the concept map is not a common condition even though research has shown that providing a quantified *root concept* has a stronger effect on the resulting concept map than providing a corresponding *focus question* (Derbentseva et al., 2006b). The *root concept* further restricts both the content and the structure of the map than the *focus question*, but a quantified *root concept* is more likely to result in more explanatory concept maps than other conditions, and we have previously explained the need to move from the commonly found descriptive concept map towards more explanatory concept maps (Cañas & Novak, 2006). Providing both a *focus question* and the *root concept* further increases the possibility of having a positive effect on the type and quality of the map constructed. For above example, providing the root concept “Quality of Education” will yield a different concept map than when providing the root concept: “Increase in Quality of Education”. The latter is more likely to reveal knowledge of both quality of education and of the impact an increase in quality would have.

4.4 List of Concepts

Providing the student(s) with a *list of concepts* (also referred to as a *parking lot*) to include in the concept map is one of the most common conditions used by educators. It is well understood that among the key aspects that lead to learning during the construction of the map is the process of building the propositions, that is, determining the most adequate linking phrases when linking the concepts. Therefore providing the *list of concepts* does not ‘give away’ good propositions to the students. But experience and research has shown that the same students construct better maps when given a *list of concepts* than under *no conditions*, and better maps than when provided with a text that includes the concepts (Soika et al., 2012). More specifically, even if the number of concepts is similar in both cases (with the given *list* and without), the structure of the maps is different. Without the *list of concepts* the students tend to use one central concept and the maps have “star” structure. With the *list of concepts* the maps have mostly more than one central concept, they have more propositions and achieve higher taxonomy score.

A less restrictive version of this condition consists of providing the *list of concepts* as a suggestion, without the requirement that they be included in the concept map. However, as educators often we are interested in making sure the students understand each and all the concepts in the list and so making the inclusion of the concepts in the map optional does not achieve this goal.

4.5 Restricting List of Concepts

A more restricted variation of the *list of concepts* condition involves limiting the students to only using the concepts provided in their concept map, leading to a stronger restriction on both content and structure. Providing a *restricting list of concepts* is an effective way of determining the students’ prior knowledge at the beginning of a study unit, and consistent with Ausubel’s assertion that “The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly” (Ausubel, 1968, p. vi).

Before describing other conditions, we clarify that there are additional elements that need to be considered when planning the conditions for the construction of a concept map by students, in particular the *process* and *purpose* or *goal* for which the concept map is built. For example, as described above the objective of building the concept map is to determine the students’ prior knowledge when beginning a unit of study, then providing a *restricting list of concepts*, even though more restrictive than a *list of concepts* or a *focus question* is appropriate. Furthermore, since we encourage that the construction of concept maps by students is a process and not a static, one time, activity (Cañas & Novak, 2005) the conditions can change during the process. For example, after beginning the unit with a *restricting list of concepts* to determine student’s prior knowledge the condition can be relaxed as students move to research the topic.

It’s important to emphasize the implications of using conditions such as the *focus question, root concept* and *list of concepts* when asking students to construct concept maps. It is clear that each of these has effects on the quality and/or type of the resulting concept map. If the concept map built by a student is a reflection of the student’s understanding of a topic, the fact that different conditions lead to different maps is an aspect that educators must consider carefully.

4.6 Expert Skeleton Concept Maps

For difficult topics – whether difficult for the students as determined by the teacher's previous experience, or difficult for the teacher because of his/her background – using an *"expert skeleton" concept map* is an alternative. An *expert skeleton concept map* has been previously prepared by an expert on the topic, and permits both students and teachers to build their knowledge on a solid foundation. An *expert skeleton concept map* contains a small number of concepts selected by an expert that are key to the understanding of the topic. The intention is that the expert will be better at selecting the key concepts and expressing accurately the relationships between them. In general, it is much more difficult to build a good, accurate concept map about a topic with a small number of concepts (e.g., four or five) than with fifteen to twenty concepts. *Expert skeleton concept maps* serve as a guide or scaffold or aid to learning in a way analogous to the use of scaffolding in constructing or refurbishing a building (Novak & Cañas, 2008). The student uses the *expert skeleton concept map* as a starting point for constructing his or her concept map, often in conjunction with a *list of concepts*. Although it restricts both the freedom of content and structure, the *expert skeleton concept map* overcomes the difficulty students have of 'getting started' in front of a blank canvas.

The use of "expert skeleton" concept maps is not as extensive as we would have liked, possibly because of the extra effort required in constructing the expert skeleton maps themselves. However, O'Donnell, Dansereau & Hall (2002) have shown that "knowledge maps" can act as scaffolds to facilitate learning.

4.7 Concept Mapping Games

Using *games* as a means to introduce students to concept mapping (Cañas, 2009), in particular to the building of propositions from concepts, is an effective scheme that should be used more often by educators. Although not used extensively, the clear increase in the quality of the concept maps resulting from the use of *games* is worth analyzing.

We first used *games* as a means to introduce students to concept mapping at the Conéctate al Conocimiento Project in Panamá (Tarté, 2006). Both the Conceptual Deck (Giovani et al., 2008) and the Conceptual Dice (Hughes et al., 2006) report results of the use of a ludic environment where students are presented pairs of concepts and have to come up with a linking phrase that meaningfully links the concepts forming a valid proposition. Both *games* consist of very restrictive conditions in terms of freedom of content and structure, where students are given a set of concepts and their only input is the linking phrases that link the concepts. The concept map is formed from the propositions developed by the students as the game progresses. Figures 2 is the concept map resulting from an experimental setting where a group of students constructed the concept map while 'playing' the Conceptual Deck *game*. Figures 3 and 4 show control groups that were provided with the same concepts in the deck but presented as a *list of concepts.* The topic was the elementary school student's favorite cartoon, "The Fairly OddParents," with which all students were familiar. The reader certainly can ascertain the difference between the concept map in Figure 2 and the concept maps in Figures 3 and 4 is obvious. The significant difference between the maps as assessed using the topological taxonomy (Cañas et al., 2006) and the semantic scoring rubric (Miller & Cañas, 2008b) is reported by Giovani et al (2008).

The large difference in both structure and content between the concept map created through the *game* and the concept maps based on a *list of concepts* shows the danger of not really understanding "what the concept map tells us" regarding the student's understanding of the domain. In this case, the lack of experience in concept mapping by the elementary school children was easily overcome by the conditions limiting the structure and content that were part of the rules of the *game* resulting in a complex concept map, while at the same time were overwhelming for the students in the control groups that were presented with only a *list of concepts*. Given that all students had basically the same level of understanding of the domain, the differences in the resulting concept maps confirm our concern with understanding how the different conditions given to the process have an impact of the resulting concept maps. Ruiz-Primo *et al.* (2001) argue that low-directed tasks such as the cases of *no conditions* and *list of concepts* demand more content knowledge and may appear too difficult for students with less competency. In this case, these students, as competent student as those playing the game, could not deal with the *list of concepts* condition.

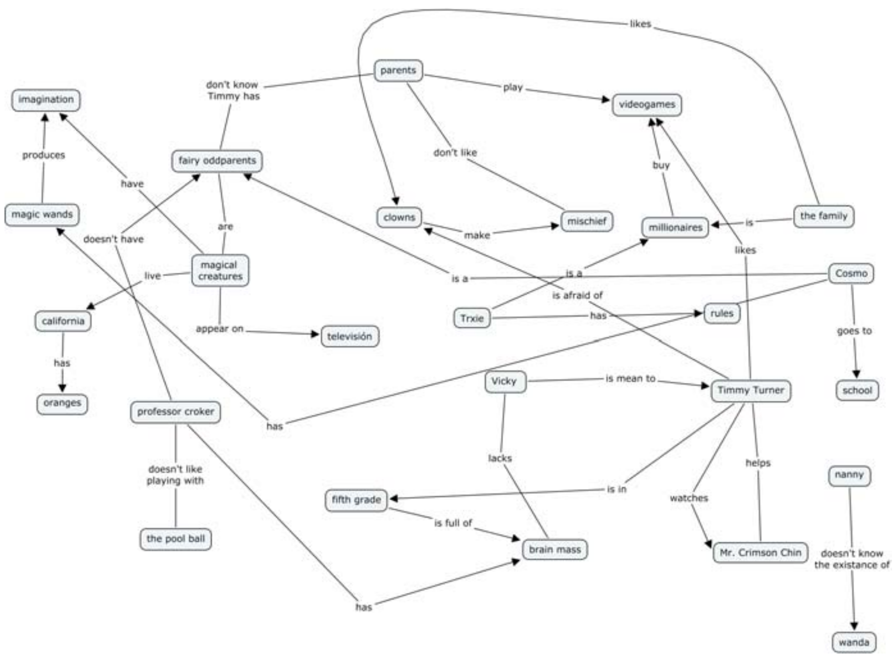

Figure 2. Cmap constructed collectively by the experimental group playing the conceptual card game (Giovani et al., 2008).

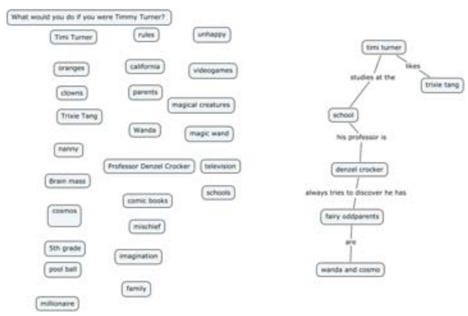

Figure 3. Cmap constructed by control group 1 playing the conceptual card game (Giovani et al., 2008).

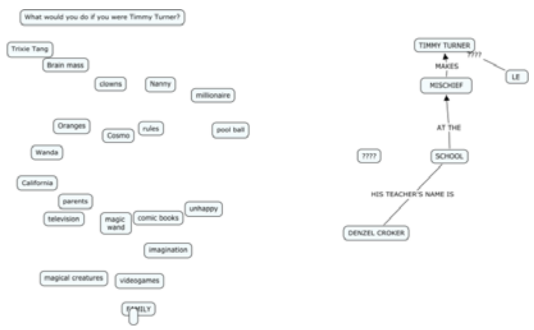

Figure 4. Cmap constructed by control group 2 playing the conceptual card game (Giovani et al., 2008).

4.8 Fill-in-the-Cmap

One approach for using concept maps without requiring student to learn how to build then is to provide a teacher-made concept map with empty cells instead of concept labels or linking phrases. Students are then required to fill in the correct concept label for each empty cell (Surber, 1984). This usually encourages rote learning, since it is usually not obvious where the correct labels should be. One variation of this technique is to provide a *list of concepts* to be used to fill in the empty cells, but this also can lead to essentially rote learning for a "correct" concept map. In general, we do not recommend either of these techniques, although their use appears in the literature (Schau et al., 2001) and have been incorporated into concept mapping software tools (Gouli et al., 2003). Under this *condition* there is no structural freedom as the concept map is already constructed; when students are given *the list of concepts* additionally there is no freedom of content. Ruiz-Primo *et al.* (2001) discuss how high-directed tasks like this *condition*, where students have little freedom to express their knowledge structure, are most likely to misinterpret the student's knowledge structure. Moon *et al.* (2010) have suggested a variation of this condition by offering multiple-choice options when filling the empty cells, providing some more freedom of content.

4.9 Memorize the Concept Map

Another approach that has been used to avoid student's need to learn how to construct good concept maps is to provide teacher-made concept maps and urging students to memorize these. The assumption here is that once students learn the hierarchical web of concepts and propositions, this knowledge will become part of their cognitive structures. Unfortunately, meaningful learning does not work this way. Information in memorized concept maps is not integrated with other relevant knowledge and enhancement of the learner's functional knowledge of this domain does not occur. Bogden (1977) found that expert-made concept maps provided to a sample of students in a college genetics course did not enhance learning, when compared with a "control" sample not receiving the maps. In fact, many from the first sample group reported that they made little use of the concept maps provided. Again we see evidence to support Ausubel's (1968) theory that describes the need for learners to be actively engaged in assimilating new concepts and propositions into their cognitive structures. Concept maps can facilitate this process only when students are engaged in the processes of good concept map construction. We are not surprised when students don't do well in tests after being given by their instructors an already constructed concept map to study (e.g., Baumgartner & Fonseca, 2012). Under this condition there is no structural or content freedom as the concept map is already constructed.

5 Discussion and Implications for Assessment

We have discussed how different *conditions* can affect the quality of the concept maps constructed by students. Educators who are aware of this can take advantage of it, using different conditions for different purposes. During the iterative concept mapping process proposed in the New Model for Education (Novak & Cañas, 2004) there is ample room to apply different *conditions* during the process. The impact of using different conditions must also be taken in account if the concept maps are being assessed. Although there are basic measures of structure and content which can be used under different settings, assessment of concept maps is highly dependent on the way the maps were created and the propose of assessment. The same measures don't have the same meaning under different settings. To use a simple example, a measure like "number of concepts" has different meaning depending on the task of map creation. If the task is to connect as many concepts to each other as possible, then the meaning is different than if the task is to find as many connections between 10 concepts as possible. This means that to correctly interpret the concept mapping data ("what does this concept map tell us?") we need to consider not just the maps' measures but also all the *conditions* of construction, in particular the freedom and restriction of structure and content as described above. As a result, it is extremely difficult to automate concept map assessment.

Educators using concept mapping for assessment should ensure that the assumptions underlying their approach are valid. It is not appropriate to compare maps from different studies if the conditions are not the same. But based on maps that are made under equal conditions, we can reach conclusions about the mapper's knowledge – persons with more knowledge make better maps. Even if it is difficult to fulfill criteria for validity under the different conditions, concept mapping is a useful tool for assessment.

6 Conclusions

The principal purpose for concept mapping in education is to assist learners in building powerful knowledge structures in whatever domain we choose to teach. The universe is made up of events and objects, and the central purpose of education is to help learners develop rich meanings for the concepts that label these events and objects. Concept maps were developed explicitly to aid this process and to serve as a tool to identify the extent to which a learner has succeeded in building powerful meanings. The kinds of *conditions* described in this paper we choose to use to assist our students in learning can radically influence the process of meaningful acquisition concepts and concept map construction. Similarly, the *conditions* we use will influence the quality of the assessments we make using concept maps. The saying "One hand washes the other" operates in education in that the quality of instruction influences that quality of learning and this in turn influence the quality of the assessment of learning that we can make. Simple as this may appear on the surface, in practice this is not always so easy.

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