Concept Maps: Theory, Methodology, Technology
Proc. of the Second Int. Conference on Concept Mapping
San José, Costa Rica, 2006

A STUDY OF LINKS IN CONCEPT MAPS CONSTRUCTED BY PRIMARY SCHOOL LEARNERS

María Reyes Fiz Poveda, Universidad Pública de Navarra. España. Natividad Iraizoz Sanzol, Colegio Público San Juan de la Cadena de Pamplona. España. y María Jesús Tabar Oneca, Universidad Pública de Navarra, España
Email: reyesfiz@unavarra.es

Abstract. This study forms part of a wider research project, in which the main aim was to observe changes in learners' cognitive structure, through the analysis of indicators such as an increase in the number of concepts included in their maps and the number and complexity of the relationships made between them. This study will focus on the second stage of the research, that is, the analysis of the number and validity of the *links* between concepts in the maps drawn by forty-one 5th grade students at a primary school in Pamplona (Spain). The project is inscribed within the context of Ausubel's theory of meaningful learning. The investigation consisted in the detection and analysis of changes in the students' maps before and after instruction. Except for two cases of pupils who failed to make any valid propositions, the rest of the maps contained a greater number of valid propositions and the *statements* the learners used to link the concepts are fully consistent with the logic of the discipline.

1 Introduction

According to the constructivist model of the Teaching-Learning process, a learner's cognitive structure is the organisation of knowledge in her long-term memory (Pines, 1979), which is constructed and reconstructed in an on-going process that continues throughout the subject's life. A person's cognitive structure is enlarged when new knowledge is acquired, but, at the same time, it is modified and restructured when the new knowledge has to be linked with and integrated into the existing structure.

Concept mapping is a tool to aid meaningful learning, developed by Novak during the 1970s and based on the Ausubel-Novak learning theory (1987). Concept maps were defined by Novak (1982) as a technique that serves at once as a learning strategy, a means to make as much sense as possible of a topic, and a method to schematically represent a series of concepts within a propositional framework. This technique has since proved an extremely useful tool for teachers and educational researchers. Numerous studies have revealed that concept mapping aids pupils to achieve meaningful learning.

2 Research plan

2.1 Objectives

- To observe the evolution of the concept maps produced by students before and after instruction.
- To obtain information from the pupil's learning, through the analysis of the following indicators: an increase in the number of links included in the maps and the complexity of the relationships between them.
- To check the effectiveness of concept maps as a learning and evaluation tool.

2.2 Method

The sample was made up of 41 Primary School children in a school in Pamplona (Spain). The children had some experience of concept mapping, both manual and computerised, in the latter case using CmapTools (Cañas etl al, 2004) created at the IHMC (Institute for Human and Machine Cognition).

The *instructional sequencing* followed the model proposed by Novak in his LEAP Project (1995) with three stages: *Introduction*, determine the students' current cognitive status. *Focusing*, instruction and learning activity. *Application*, in which all the knowledge acquired in the previous stage is then applied.

The instruction plan was drawn up from a concept map consensuated between several teachers (Fig. 1). This contained the concepts that would be used in the instruction and in the construction of the individual maps. It also showed the hierarchical relationships and integrative reconciliation between the concepts and the most significant conceptual nodes. The chosen topic was the measurement of magnitudes, since this was considered a key topic in Primary school mathematics. (Resnick and Ford, 1990). It involves the ability to handle and apply a large amount of the course content of previous years such as: understanding of the number system, decimal and hexadecimal bases, mathematical operations, working with decimals, multiplication and division by numbers followed by zeros.., the use of highly specific vocabulary, etc.

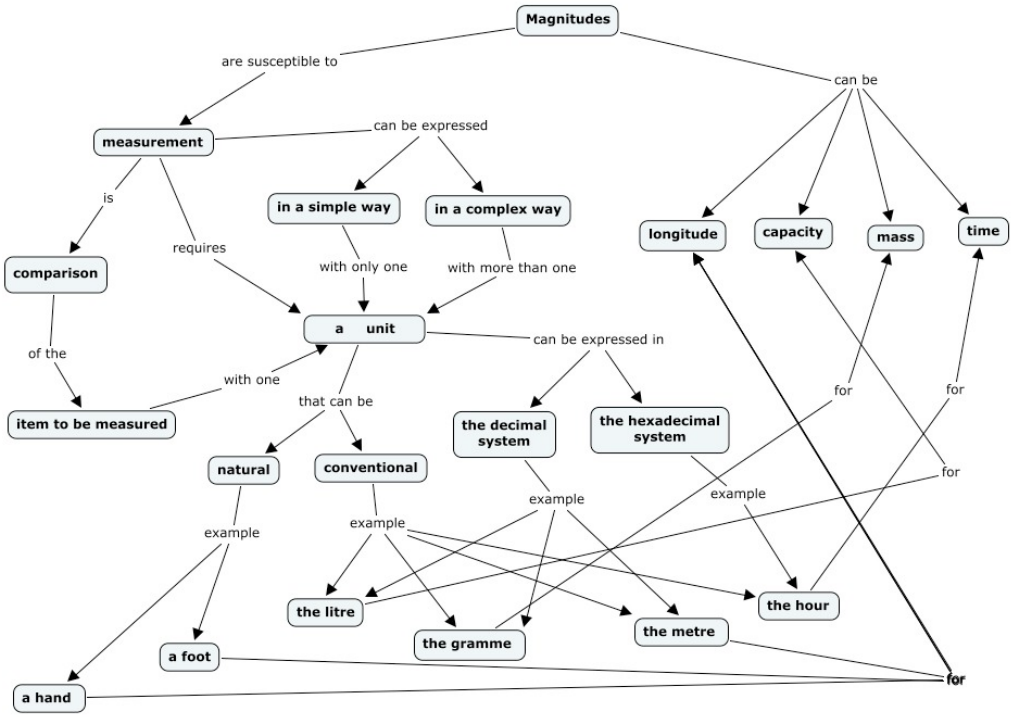

Figure 1. Concept map drawn by four teachers to identify conceptual nodes and significant links

2.3 Results and discussion

The maps were evaluated according to the following criteria:
Use of proposed concepts.
Number and quality of links.
Hierarchical ordering of concepts.
Number and quality of cross-links.

In this study, we present the results of the second of these criteria, the number and quality of the links**.** Information relating to the concepts becomes more meaningful when one studies the links between them (the formation of propositions) and the way (order, hierarchy) in which they are arranged on the map. Some interesting findings emerge from Table, which gives the children's results in the initial and final maps, together with the number and percentage of their correct and incorrect propositions plus the variation in these.

The links were evaluated according to the following criteria:

- For a proposition, or *linking statement* to be considered valid, it must show a clear and explicit relationship between the concepts and, of course, be consistent with the logic of the discipline.

- Vaguely worded propositions such as: can be, has, are, the, of …etc, and those without labels cannot therefore be considered valid, since they contribute nothing to the formulation of a real proposition.

Pupil	Propositions initial map	Incorrect	Percentage incorrect	Correct	Percentage correct	Propositions Final map	Incorrect	Percentage incorrect	Correct	Percentage correct	Variation	Increase / decrease
1	20	20	100	-		21	13	61.9	8	38.1	1+	+
2	22	12	54.55	10	45.45	41	2	4.88	39	95.12	19+	+
3	28	20	71.4	8	28.6	36	28	77.88	8	22.22	8+	+
4	18	16	88.9	2	11.1	17	14	82.4	3	17.6	1-	+
5	29	13	44.83	16	55.17	37	31	83.29	6	16.21	8+	-
6	16	9	56.25	7	43.75	25	18	72	7	28	9+	+
7	26	26	100	0		42	37	88	5	12	16+	+
8	15	11	73.3	4	26.7	31	13	53.84	14	45.16	16+	+
9	12	12	100	0		23	17	73.9	6	26.1	11+	+
10	19	2	10.53	17	89.47	25	6	24	19	76	6+	+
11	12	12	100	0		19	19	100	0		7+	+
12	3	3	100	0		17	14	82.35	3	17.65	14+	+
13	18	17	94.5	1	5.5	29	13	44.12	16	55.18	11+	+
14	12	12	100	0		27	24	84.4	3	15.6	15+	+
15	15	9	60	6	40	32	27	84.4	5	15.6	17+	+
16	13	9	69.2	4	30.8	31	18	58	13	42	18+	+
17	16	8	50	8	50	25	20	80	5	20	9+	+
18	30	27	90	3	10	35	22	67	11	33	5+	+
19	23	16	56.25	7	43.75	35	16	46	19	54	12+	+
20	7	7	100	0		8	8	100	0		1+	+
21	23	17	64.8	6	35.2	26	21	80.77	5	19.23	3+	+
22	22	20	91.9	2	9.1	20	18	90	2	10	2-	-
23	10	10	100	0		13	9	69.23	4	30.77	3+	+
24	14	13	92.86	1	7.14	25	23	92	2	8	11+	+
25	23	10	43.5	13	56.5	35	9	25.72	26	74.28	12+	+
26	26	16	69.54	10	30.46	34	10	29.4	24	70.6	8+	+
27	20	20	100	0		27	14	70.4	8	29.6	7+	+
28	21	7	33.3	14	66.7	36	31	86.1	5	13.9	15+	+
29	27	18	66.6	9	33.3	30	18	60	12	40	3+	+
30	20	11	55	9	45	29	15	51.7	14	48.3	9+	+
31	19	12	63.2	7	36.8	33	33	100	0		14+	+
32	40	18	45	22	55	57	5	8.88	52	91.22	17+	+
33	12	11	91.66	1	8.33	30	28	93.3	2	6.7	18+	+
34	10	10	100	0		12	12	100	0		2+	+
35	19	17	89.47	2	10.53	25	17	68	8	32	6+	+
36	21	19	90.48	2	9.52	27	20	74	7	26	6+	+
37	45	18	40	27	60	-	-	-	-	-		
38	18	16	88.9	2	11.1	27	26	96.3	1	3.7	9+	+
39	25	14	66	11	44	39	27	69.2	12	30.8	14+	+
40	13	13	100	0		31	31	100	0		18+	+
41	25	22	88	3	12	31	31	100	0		6+	+

From this table it can be seen that:

- Thirty-seven of the forty-one students make more valid propositions in the final map than in the initial map. The increase ranges from one more proposition to nineteen more.
- Four categories have been established based on the validity of their linking statements:
    - First level, 7 students who managed to make between 1 and 5 valid propositions (17.5% of the sample).

    - Second level, 13 children who made between 6 and 10 valid links (32.5% of the sample).
    - Third level, 10 students who made between 11 and 15 valid propositions (25% of the sample).
    - Fourth level, 8 children who made between 16 and 20 valid links (20% of the sample)

- Only two children made fewer propositions in the final map than in the initial one.
- One child did not draw the second map.
- Overall, the initial maps contained a total of 807 valid propositions (which is an average of 19.7 per child), while the final maps contained a total of 1.123 propositions (an average of 28.1).

3 Educational implications

By analyzing the *links* it is possible to find out whether the child is able to make sense of her prior knowledge, and discover possible conceptual errors. Analysis of the *statements* enables the teacher to identify missing connections between concepts and thus detect any erroneous concepts that would indicate the child's need for further learning.

We propose the use of concept mapping as a working tool for both learning and evaluation, since it creates a learning environment and yields information that would be difficult to obtain via the more traditional methods used in schools.

Concept maps can be useful when used within the framework of the meaningful learning theory (they are not to be confused mere schematic outlines or other concept-linking diagrams). They allow students to interact and work out meanings through negotiation, which is key to promoting real conceptual change, and thus overcome the serious problem of conceptual errors (González, Morón and Novak 2001).

Students gradually become aware of what they do and do not know. If controlling one's own progress is a key metacognitive activity, concept mapping enables pupils to control their own learning process. Through the use of concept maps, pupils are taught metacognitive skills that are fundamental to school learning, and tend to be lacking in very young children. This enables them to develop learning strategies such as, hierarchical ordering, differentiation, reconciliation... In addition, concept maps are effective in increasing motivation, thus helping to raise self-esteem (González and Iraizoz, 2001).

A constructivist approach to the teaching-learning process should include concept mapping as a learning strategy, because it forces learners to negotiate, share meanings and reflect on what they have constructed.

4 References

Ausubel, D., Novak, J & Hanesian, H. (1987). *Psicología educativa*. *Un punto de vista cognoscitivo*. México: Trillas.

Cañas, A. J., Hill, G., Carff, R., Suri, N., Lott, J., Eskridge, T., et al. (2004). CmapTools: A Knowledge Modeling and Sharing Environment. In A. J. Cañas, J. D. Novak & F. M. González (Eds.), *Concept Maps: Theory, Methodology, Technology. Proceedings of the First International Conference on Concept Mapping* (Vol. I, pp. 125-133). Pamplona, Spain: Universidad Pública de Navarra.

González, F. M. & Iraizoz, N. (2001). Los mapas conceptuales y el aprendizaje significativo. *Alambique*, 28, 39-51

González, F.M., Morón, C. & Novak, J. (2001). *Errores Conceptuales. Diagnosis, Tratamiento y Reflexiones*. Pamplona. Ediciones Eunate.

LEAP Projet (1995). Cornell University. Ithaca. New York.

Novak, J. D (1982). *Teoría y práctica de la educación*. Madrid. Alianza Universidad.

Pines, A.L (1979). *The modifield Piagetian Clinical interview (MPCI) and Conceptual Propositional Analysis (CPA) as Methods for Evaluating Cognitive Structure*. Paper presented at the National Science teacher Association (INSTA). Annual Convention in Atlanta, Georgia.

Resnick, L. & Ford, W. (1990). La enseñanza de las matemáticas y sus fundamentos psicológicos. Barcelona: Paidós.