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IS IT POSSIBLE TO IMPROVE MEANINGFUL LEARNING IN MATH IN PRIMARY SCHOOL LEARNERS?

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Abstract. This paper deals with the use of concept maps as a tool for the teaching and quantitative- qualitative assessment of math in primary school learners. The results indicate significant optimisation in the *use* of the concepts involved in the topics, and a noticeable improvement in the cognitive structure of the learners, who store the concepts in their long-term memory in a more *orderly* and *hierarchical* fashion than when taught by means of rote learning techniques. The authors conclude that concept maps is an extremely valuable tool to enhance meaningful learning in pupils. They therefore recommend them for use in the teaching/learning of math at primary school level.

1 Introduction

This poster is drawn from a study aimed at detecting and analysing changes in the concept maps constructed before and after instruction by forty-one 5th grade (11 year old) primary school pupils at the "*José Mª Huarte*" state school in Pamplona (Navarra) - Spain. It is inscribed within the Theory of Meaningful Verbal Learning proposed by D. Ausubel, Novak and Hanesian (1987) on the basis of which, Novak (1988) developed his idea of Concept Maps, which have long been recognised in the field of Educational Psychology as an excellent technique to help pupils to achieve meaningful learning.

2 Research Plan

2.1 Objectives:

- To create a meaningful learning environment.
- To use concept maps as a tool for learning and assessing progress in a math topic (measuring magnitudes).
- To test the effectiveness of this tool by observing the evolution of the concept maps produced by students before and after instruction.
- To detect changes in students' cognitive structure by comparing the number of concepts included in the initial and final maps, and how they are arranged and hierarchically ordered.

Measuring magnitudes was chosen as a key topic in primary school math (6-12 year olds). This process resulted in the identification of the following concepts to be used at different stages of the investigation: *magnitudes, measurement, item to be measured, comparison, units, complex way, simple way, longitude, capacity, mass, time, natural, conventional, hand, foot, metre, litre, gram, hour, multiples, submultiples, change, minute, second, decimal system, hexadecimal system.*

2.2 Method

A. Training in the construction of concept maps.
B. The students' prior knowledge of the measurement of magnitudes was assessed by means of pencil and paper tests and they were then asked to draw individually a concept map of the topic (initial map).
C. A six weeks' instruction period then began following the model proposed by Novak in his LEAP Project (1995).
D. The students were asked to draw (again individually) another map of the concepts presented during the instruction period, two months after it finished (final map).

This poster presents the evaluation of the maps based on two criteria (González, Morón & Novak, 2001): a) Use of proposed concepts. b) Arrangement and hierarchy of concepts used.

2.3 *Presentations and Discussion of the Results*

2.3.1 Use of proposed concepts

By means of a comparative global analysis we were able to observe that, after instruction, there was a clear, overall improvement in the number of concepts used by the learners (in all cases except one):

- Initial map: Eleven students (26.82%) used between seven and thirteen concepts (17% to 31.70%) and the rest between fourteen and twenty-one (34.14% to 51.21%). Very few used more than 50% of the concepts. The average was 15.2 concepts per map (30 %).
- Final Map: Only two students used fewer than 50% of the proposed concepts, while the rest used between fourteen and sixteen (53.8% to 61.53%). The average number of concepts per map was 21.8 (80.76%).

Thus, the average number of proposed concepts used in the maps increased by more than 50%. We can therefore be satisfied that the instruction in the use of the concepts was effective. Furthermore, the final maps featured additional concepts and examples together with a greater tendency to relate them to prior knowledge.

Table 1: Numbers and percentages of students using the concepts in the initial and final maps in descending order of the variation in usage.

Sample: 41 subjects	Initial Map		Final Map		Changes	
Concept	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**
Longitude	40	98.5	38	92.5	-2	-5
Gram	40	98.5	38	92.5	-2	-5
Metre	40	98.5	40	98.5	=	=
Litre	39	95,00	39	95	=	=
Foot	37	90.24	38	92.5	+1	+2.5
Time	37	90.24	40	98.5	+3	+7.3
Minute	37	90.24	41	100	+4	+10
Second	37	90.24	41	100	+4	+10
Hand	36	87.8	38	92.5	+2	+5
Hour	36	87.8	41	100	+5	+12.19
Capacity	35	85.4	37	90.24	+2	+5
Mass	35	85.4	38	92.5	+3	+7.3
Measurement	34	83	39	95	+5	+12
Units	31	75.6	35	85.4	+4	+10
Magnitude	25	61	39	95	+14	+34
Hexadecimal system	24	58.53	37	90.24	+13	+31.7
Multiples	20	48.78	34	82.92	+14	+34.14
Submultiples	20	48.78	34	82.92	+14	+34.14
Decimal system	19	46.34	35	85.4	+16	+39
In a simple way	10	24.4	35	85.4	+25	+61
In a complex way	10	24.4	33	80.5	+23	+56
Item	9	22	26	63.45	+17	+41.46
Changes	7	17	27	65.85	+20	+48.78
Comparison	5	12	15	36.5	+10	+23.5
Natural	5	12	25	60.97	+20	+48.78
Conventional	4	9.75	26	63.5	+11	+26.8

Caution is due when interpreting the notable improvement in the number of concepts used, since it was observed in the final maps that some students had become obsessed with trying to use all of the proposed concepts. Several students explicitly expressed their satisfaction at having been able to include them all; which was an achievement they equated with successful learning. This gave rise in more than one case to their trying to find "ad hoc" or contrived explanations, even if it meant going outside the subject area. For an easy visual representation of the improvement in the use of concepts in number and percentage terms between the initial and final maps produced by the students, we present Table 2 when we can see that:

1. Twenty-five (96.15%) of the twenty-six target concepts are included in the final maps of 60% of the students, whereas, in the initial map only 15 (57.69%) of the concepts were used by 60% of the students.
2. The concepts used by fewer than 25% in the initial maps, were used by a very high percentage of students in the final maps: *in a complex way, in a simple way and item to be measured* went from under 25% to between 80 and 89%; *change, natural and conventional* from 10% to between 60 and 69%.

3. The use of *Decimal system, hexadecimal system, multiples and submultiples* increased considerably, from 40-59% to 80-89%. The use of *magnitudes* improved noticeably, increasing from 61% to 95%; finally, *measurement* became one of the most widely used concepts, having been incorporated by 95% of the students, that is, the same percentage that in the initial map used *hour, minute and second,* which in the final map were included by 100% of the students.
4. While in the initial map seven of the concepts were used by less than 25% of the students, in the final map there was only one concept that was used by less than 40%. This was *comparison*, which was used by 36.5%. Note, however, that, since it was used by only 12% of the students in the initial map, this was a considerable increase (23.5%).

Table 2: Concepts used in the initial and final maps grouped by percentages

Percentages	Initial Map	Final Map
100 %	0	Minute, second, hour
90-99 %	Gram, metre, litre Longitude, capacity, mass, time Hand, foot	Gram, metre, litre Longitude, capacity, mass, time Hand, foot Magnitude, measurement
80-89 %	Hour, minute, second, Measurement	In a complex way, in a simple way Decimal system, hexadecimal system Multiples, submultiples
70-79 %	Units	Units
60-69 %	Magnitudes	Item to be measured Changes Natural, conventional
40-59 %	Decimal system, Hexadecimal system, Multiples, submultiples	0
25-39 %	0	Comparison
25-15 %	In a complex way, In a simple way, Item to be measured	0
= or < 10 %	Changes, comparison Natural, conventional	0

To conclude with respect to the first of the aspects evaluated, we would like to clarify that the mere inclusion of a concept on the map is not considered correct usage. Students frequently give explanations that are not consistent with the logic of the discipline they may even use them out of context in their zeal to incorporate them in the map. Thus, these initial data cannot be interpreted without taking into account the second aspect that was evaluated: arrangement and hierarchical ordering of the concepts.

2.3.2 Arrangement and hierarchical ordering of concepts

Gradual differentiation and integrative reconciliation, identified by Ausubel (1987) as meaningful learning indicators, can be assessed in this context by observing the arrangement of the concepts into successively lower levels of abstraction and the hierarchy established between them by the students in their maps. For these indicators to be present, the learner needs to have understood which contents relate to the topic and also to have understood the way in which they are related to one another. The observed outcome was that our students were able to construct more elaborate maps with a deeper level of significance and greater consistency; we could say that the procedure enabled the learners to progress from beginners to experts (Chi and Glaser, quoted by Flavell, 1984). Close observation of our students' final maps clearly shows that, after instruction, they were able to make more linkages between concepts. Most of them place a fairly abstract concept (often *magnitudes*) at the top of the map, while keeping the lower part of the map for more concrete concepts (usually different *units*). In between they fit intermediate concepts such as longitude, capacity, mass and/or time (*types of magnitude*).They are less precise when positioning intermediate abstract concepts, such as: *units*, *measurement*, *decimal system*, *hexadecimal system*, etc.

The assessment criterion for the arrangement of concepts was that they should appear in the following three levels of inclusively: *magnitude / types of magnitude /types of units*. The hierarchical ordering of the concepts was evaluated by the intermediate positioning of factors such as: *units, measurement, systems*, etc., defined earlier as intermediate concepts. Table 3 shows the results of the assessment of these two aspects.

Table 3: Assessment of the arrangement and hierarchical ordering of the concepts on the initial and final maps

Initial Map	**Yes**	**Percentage**	**No**	**Percentage**
Are the three levels of inclusive indicated?	20	48.78	21	51.21 %.
Are the intermediate concepts correctly positioned?	0	0	42	100 %
Final Map				
Are the three levels of inclusive indicated?	28	68.30 %	13	31.70 %
Are the intermediate concepts correctly positioned?	6	14.63 %	35	85.36 %

It can be seen from this table that there was a significant improvement in the arrangement of the concepts between the initial and final maps. Eight more students *inclusively use three* levels of, which is an increase of 19.5%. This finding is hardly surprising, given that the concepts in question are ones with which the students are very familiar, having worked with them all the way through Primary School. *No correct positioning of intermediate concepts* was found in the initial maps, whereas six students (14.63% of the sample) succeeded in positioning them correctly in the final maps. This is admittedly a low percentage but hardly surprising bearing in mind that it is quite common for learners of this age to have difficulty in positioning intermediate concepts when concept mapping in other science areas. They often go straight from the more inclusive to the more concrete concept without making the necessary abstraction to create new concepts.

3 Final remarks

It is hard to find an explanation for the fact that 30% of the students still fail to use *natural, conventional, changes and item to be measured* in their final maps. This is especially surprising in the case of the first two, which, as well as being the ones they had handled most in previous school years, had been heavily emphasised during instruction, where attention had been drawn to the disadvantage of using natural measures, because of their lack of reliability with respect to conventional ones. It was also disconcerting to find so little improvement in the use of *units*, especially after the students had scored so well in the standard tests for converting from one unit to another. It is easier to account for the low level of usage of the concept *comparison* at the beginning and end of the instruction period. Several years' experience working with 5th grade primary students has shown us that *children do not really think about what measuring means or are at least unable to express it verbally*. Their difficulty increases when they are working with large (multiples) or very small units. The kind of activities that appear in textbooks in relation to this issue do not aid their understanding; they reduce it to simple unit conversion via mathematical calculation. We would like to alert the authors of these textbooks to the need to address this shortcoming.

When it comes to the arrangement and hierarchical ordering of the concepts, our findings irrefutably reveal that in the teaching/learning process for scientific topics, it is in the arrangement and hierarchical ordering of the concepts by the students where the teacher's intervention is most needed. Teachers can help by negotiating the meaning of the concepts with each student on an individual basis. As a final consideration, we would say that it is good teaching practice to use concept maps as a learning and assessment tool to enhance students' understanding of mathematical concepts. However concept mapping is more difficult in mathematics than in other areas, because mathematical concepts are both more abstract and highly interdependent and are difficult for primary school pupils to express. Math teachers need to be aware of this difficulty, but we should persevere in using them because they can help our students to learn in a much more meaningful.

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