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CONCEPT MAPS IN TEACHING AND LEARNING PROCESS OF RATE OF CHANGE CONCEPT

Pedro Vicente Esteban Duarte, Paula Andrea Rendón Mesa
Universidad EAFIT, Colombia
{pesteban, prendonm}@eafit.edu.co

Abstract. The implementation of concept maps in the classroom allows both the teacher and the student discovering and describing meaningful relations among the concepts object matter of the study (Novak & Gowin. 1988), making it possible to create connections between them and the context in which activities are developed. That is the reason why teaching and learning process are related to the rate of change, in order to provide students with a tool which allows them evidencing in an organized way several relations of the concept to events of the environment, such as a plant's growth in relation to time, a country's currency price variation with respect to other country's currency, water temperature variation when submitted to a burner in relation to time, etc.

1. Reference Framework

During the first years of education, mathematics faces students with situations in which they can use algorithms such as those from addition, subtraction, multiplication, division, among others, in order to relate two magnitudes which do not vary, from which an answer having the same characteristics is obtained. At the end of the basic education cycle, algebra studies begin; it introduces "variables" which can have several meanings according to the context from which stated problems have been extracted. From a mathematical point of view, this school pathway is characterized by going from arithmetical studies to algebraic studies. This brings new challenges to students, as operation alternatives are wider, new and different meanings are given to the answers, which require a maturity period of these new concepts to be understood.

When basic school cycle ends, the concept which synthesizes studied change processes is the *rate of change* which can be modeled, in situations where variation is continuous, from straight line equation $y = mx + b$, where m is the value representing variation relation among observed phenomena. Understanding this concept represents new challenges for students from different points of view: from language point of view, handling new mathematical expressions; the meaning of each one of the equation terms according to the context from which variables object matter of this study have been extracted; graphic representation, among others. Concept maps are a good tool which allows teachers realize the assimilation of the rate of change concept.

1.1. Rate on change in High School Education

Calculus is considered as one of the most important areas within mathematics, as it makes it possible to understand several nature phenomena from equations which model them. If students want to reach success in this field, they need to be provided with a training which is consistent with the *variation thinking*,[1] as it has been called in their school program "to presuppose overcome teaching of fragmented and divided mathematical contents in order to place us in the domain of a conceptual field involving inter-structured and linked concepts and procedures which allow mathematically analyzing, organizing, and modeling situations and problems from both man's practical activity and sciences and mathematics, where *variation* is found as their substrate." (Ministerio de Educación Nacional de Colombia, 1998).

Rate of change involves *variation* of magnitudes which should be measured and compared. These activities are performed by students as natural processes related to different knowledge situations or areas, such as geometry, administration, natural sciences, etc., which make teaching of change concept a useful tool "to prepare students for studying calculus, which has been a basic goal of school mathematics; to state and resolve calculus equations is a vital element of traditional engineering-focused mathematics" (Stewart, 1998).

The teacher is responsible for involving methodological intervention strategies in the classroom to promote exploration, discovery, and construction of mathematical ideas in teaching and learning process. Specifically speaking on the rate of change concept, this makes easier to understand proportionality relation between two variables, thus providing learning with meaning.

1.1 Concept Maps in Mathematical Teaching

Stated teaching strategies which are executed by mathematics teachers to present mathematical concepts throughout an academic period are an important factor for students to learn them. As a concept map "is a visual representation of the hierarchy and relations among concepts within an individual's mind" (González & Novak, 1993), it is a resource which evaluates relations made during a process to learn the concepts under study. This fact is particularly important for teaching mathematics, which objective is to make individuals learn several hierarchical structures which make sense in applications carried out in other knowledge fields.

The use of concept maps in *rate of change* teaching was intended to make students discover by themselves, from the very first exploration stages of the concept, different manifestations in their environment and relate them from both differences and similarities. The following are the way by which they were taken to the classroom and results obtained.

2 Classroom Intervention Integrating Concept Maps in Teaching-Learning Process of the Rate of change

The experience was carried out in 2007 during three months at Institución Educativa Pedro Luis Álvarez Correa located in Caldas (Antioquia, Colombia). Exercises to construct concept maps about previously studied mathematical topics were carried out with the students. At the beginning, the group was informed about the objectives of the work to be performed and results expected from each student at the end. This is the way how concept maps were used in the classroom intervention.

2.1 As a Learning Pathway

According to Novak's own words: "a concept map can also act as a 'roads map' where some routes are shown to be followed for connecting concepts meanings in such a way that propositions can be achieved" (Novak & Gowin. 1988). This implies an "academic program planning" for teachers, which is reflected on their activities, allowing students making questions such as: What am I going to learn? What can I use this learning for? What applications does this topic have in the context? Among other aspects.

After the discussion, students posed questions such as: What does a change stand for? How do we realize a change has occurred? In which daily life situations changes or variations occur? Which is the importance of the change? How do changes are measured? Etc. In order to give answers to such questions, interviews to people from different professions and occupations were proposed to be performed.

Answers provided by interviewees showed two kinds of change: A qualitative change considered as a transformation from one state to another, as a change of color and a change of mood, which were referred to by people performing social activities such as priests, policemen, nurses, etc. A quantitative change related to different measures, as the income and expense of money come from sales of purchases made in a store, time spent by different cars to go over a certain distance, reported by people performing activities in which accounts are managed or measures are taken. Answers provided made it possible to create a glossary which allowed making differences among the kinds of change found, and clearly defining that during the experience the interest was focused on the quantitative change, as it can be expressed in numerical terms and, based on observations, constructing tables and graphs which account for its characterization.

2.2 To Extract Meanings and to Synthesize

After students collected information from several sources (interviews, consultations, etc.), in relation to the studied concept, they were asked to construct concept maps to synthesize the process (Figure 1).

Socialization and analysis of these maps made it possible to create hierarchies among several terms which make reference to the change and which were found during the interviews. In this work stage, achievements reached were disclosed in relation to processes involving the change, as propositions and argumentations provided were constructed from language, which are a step prior to understanding the concept from a mathematical point of view.

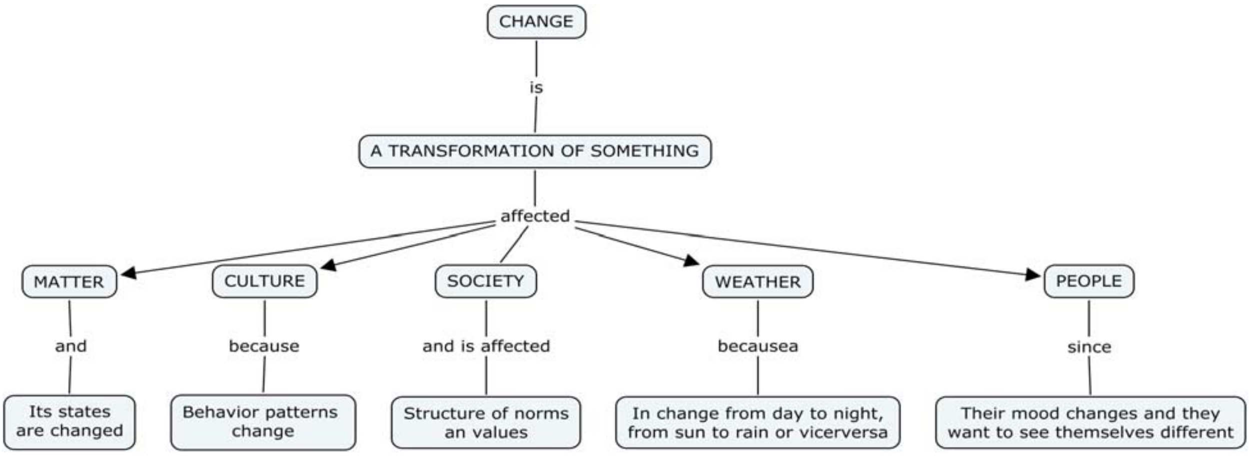

Figure 1. Concept Map Created by Students to Present Socialization Activities.

Construction of concept maps by students helped evidence differences between a qualitative change and a quantitative change, observed in different activities performed, such as. Growth of an animal, temperature records of a liter of water under fire, among others. Due to the activities nature during this part of the process, tabulation records, graphic records, and the approach to the algebraic representation (situation modeling), are basic aspects when making rate of change. Step-by-step development of aspects involved allows a conceptualization of other change manifestations such as: direct proportionality, proportionality constants, variation of magnitudes, graphic and algebraic representation of the straight line.

2.3 Evaluative Purposes

To get deeper into the rate of change concept, other statements in which they should involve change situations were proposed. In these situations, measures should be taken to construct a tabulation record divided into similar time intervals. Three-student groups were formed with the purpose of interacting and getting to an agreement about the way how a rate of change is produced in the experiment under execution and the meaning that could be given according to the used context. As a synthesis process, they should prepare a concept map on which they should support a presentation before their classmates. The final concept map should include the rate of change as its main concept.

Concept maps constructed accounts for understanding acquired by students. Also, they are very useful for teachers as an evidence of the way as each one of the parties involved in the process assumes his/her own learning. From their follow-up and analysis, experiences can be designed to help their students overcome weaknesses or to reinforce strengths acquired in learning process. it was intended that students include in the map, formalizations of algorithmic procedures or processes which allow them having correct answers from concepts and propositions explaining the phenomenon (Figure 2).

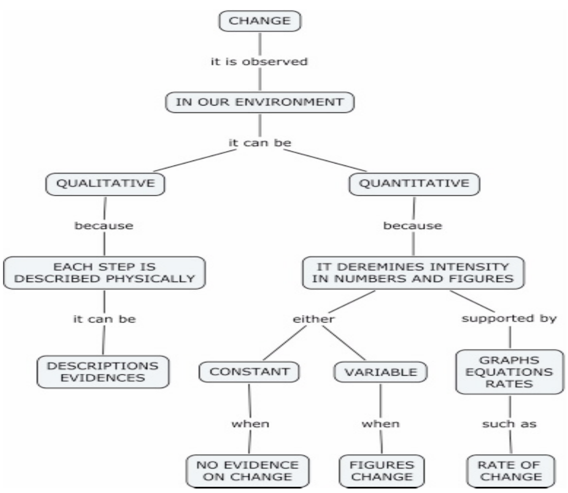

Figure 2. Concept Map Created by Students at the end of the process.

3 Conclusions

If teaching-learning educational process is considered as a goal through which students can get a meaningful learning of stated concepts, which extend and articulate their network of relations and can apply them in different contexts, it is necessary that teachers include tools to speed up act performance of agents involved in the construction of the new knowledge. In our case, applying a concept map tool in the classroom allowed students being themselves more motivated to carry out proposed activities and to participate in the construction of their own knowledge.

During the experience, we based on students' previous knowledge, in such a way that they could develop mathematical competences separated from algorithms, strengthening creative and argumentative skills which were supplemented with the design of models to let them creatively express their ideas, thus making associations of rate of change concept with surrounding phenomena which change quantitatively.

Solutions provided by students for several problems stated by them and by the teacher as well, concept maps developed as a final synthesis process, allow identifying that students, throughout the experience, reached (according to their academic level) an appropriate conceptualization of the rate of change, as they recognize it as the quotient of two magnitudes and can create tabulation records from proportional calculations, associating answers obtained with a straight line slope.

4 References

Camargo, L. & Guzmán A. (2005). Elementos para una didáctica del pensamiento variacional. Cooperativa Editorial Magisterio. Bogotá D. C. Colombia.

Cañas, A. J., Novak, J. D., Collado, C. M., Zea, C., Atuesta, M., Henao, M., & Hernández, P. (2003). Entendiendo las Ciencias a través de mapas conceptuales. IV Conferencia Internacional sobre Educación, Formación y Nuevas Tecnologías. Miami.

Díaz-Barriga F., & Hernández R.G. (2002). Estrategias Docentes para un Aprendizaje Significativo. Una Interpretación Constructivista. McGraw Hill, Segunda Edición, México.

Farfán, R. M. (1997). Ingeniería Didáctica. Un estudio de la variación y el cambio. Grupo Editorial. Iberoamericano. México.

González, F. & Novak, J. (1993) Aprendizaje Significativo, Técnicas y Aplicaciones. Madrid, España: Cincel S. A.

Henao, M. (2004). Experiencia con el Uso de Mapas Conceptuales como Estrategia de Enseñanza. Proceeding of the First International Conference on Concept Mapping: Concept Maps: Theory, Methodology and Technology. Vol. 1, pp. 325-332. Pamplona, España.

Maya, A., & Díaz, N. (2002). Mapas Conceptuales, Elaboración y Aplicación. Retina, Bogotá D. C.

Ministerio De Educación Nacional (2004). Pensamiento Variacional y Tecnologías Computacionales. Serie Documentos. Bogotá D.C Colombia.

Novak, J. D., & Gowin, D. B. (1999). Aprendiendo a Aprender. Martínez Roca, Barcelona.

Paissan, M. H. (2006). Teoría del Aprendizaje Significativo, por David Ausubel. http://www.educainformatica.com.ar/docentes/tuarticulo/educacion/ausubel/ Consultado en marzo de 2006.

Rapetti, M.V (2003). Proporcionalidad: Razones internar y razones externar. Suma: Revista sobre la enseñanza y el aprendizaje de las matemáticas. núm. 43, pp.65-70. Valencia, España.

Stewart, I. (1998). Cambio. La enseñanza agradable de las matemáticas. pp. 193-228. Limusa Noriega Editores. México.