An Alternative Method to Asses Students Knowledge About the Concept of Limit in Engineering Teaching

Carlos Troncoso*, Andrea Lavalle*, Leopoldo Curia*, Elaine Daniele**, Ricardo Chrobak*.

* Universidad Nacional del Comahue : Tel/FAX : 0054-99-488308
** Instituto Jean Piaget

Abstract

The present work has the purpose of showing the evolution of topics or mathematical concepts that are both, relevant and with marked grade of abstraction.
On this report is specifically described the utilization of Metacognitive tools. They are the Concept Maps, the Gowin's heuristic Vee and the Clinical Interview. We show that they are efficient in the inquiry about what concept have mastered the students of engineering at Comahue University. Those students had approved the corresponding course.
The Clinical Interview, the Conceptual Maps and the application of the UVE, permit the students to make an autoanalysis of their knowledge about the topic.
Also, permits the professors a critical reflection of how they are achieved their objectives, the causes of that and the change that they should carry out in order to achieve a meaningful learning of such a substantial topic.

Introduction

" To start a University career bring hopes and fears into students. Whatever the motives that move a student to register in a university career, the expectation of academic success or failure is a component that accompanies that decision. There are many and varied motives that sustain the choice of a career, there are also varied attitudes and expectations from the students about their academic performance. " (Rinaudo, 1996, Teach and Learn page 1).

"The professor explains to the student the meanings already shared by the scientific community about the educational of the curriculum.The student, also feeds back the professor the meanings that S/he understood.

If S/he fails to share the required meanings, the professor can, again, negotiate, in a different o way, the meanings accepted in the context of the subject being developed. The student, somehow, reveals, again, the meanings that s/he grasped."

"The teaching is achieved when the meaning of the material that the student grasps is the meaning that the professor intends for the student." (Gowin, 1981, p. 81)

Perhaps, one of the most well-know principles in the Constructivist cognitive is focused to the acquisition of knowledge like an assimilation process to a previous mental structure. Both the American sources with psychologists like Ausubel and Anderson; and the European approaches of Piaget and his students in the School of Ginebra, lead to the idea that the mental processes are guided by the need to give sense to the experience.

According to Ausubel when the learned succeeds in establishing non arbitrary and essential relationships between the new content and the ideas already established in his cognitive structure, s/he achieves the assimilation and learning is meaningful.

In this work the methods of clinical interview, conceptual maps and UVE diagrams, in order to analyze if the students of the career of Engineering at the UNC, have learned the concept of numerical sequences and mainly the definitio of the limit of a numerical sequence.

With this purpose, individual interviews were carried on with a group of students group that attended the course during the fall term in 1996 and the spring in 1997.

Methodology

The used methodology consisted of carrying on clinical interviews to the students that had already passed the Calculus course, recording such interviews and making the cognitive maps of every special individual.

In order to project the activities carried out with the students we used the learning UVE and in organization of the evaluation and conclusions of the researchers the heuristic UVE.

We gave the students, who participated them all the necessary explanations to improve the teacher-student interaction and we so gave a frame of sincerity to the event.

UVE SCHEME USED

CONCEPTUAL
1 **Focus Question**
2 **Object/Event**
3 Worldview
4 Philosophy
5 Theory
6 Principles
7 Concepts

METHODOLOGICAL

11 Value claims
10 knowledge claims
9 Transformations
8 Records

1. Focus Question

How did the students learn the concepts of numerical sequence and of limit of a numerical sequence?.

2. Object/ event

Clinical   interviews to students who attended and passed the subject matter in the career of Engineering.

3. Worldview:

The meaningful learning boosts students because it leads them to construct their knowledge in order, to causing gratifying feelings and personal satisfaction being the only "builders" of their knowledge. The specific topic of this work, limit a succession and the concept closely bound to it the functional limit, are the main tools in all differential calculation. The definitions of derivative and integral lean on this concepts; they are the powerful elements of application in all the branches of applied calculus.

4. Philosophy

The experience of sharing meanings leads to meaningful learning. A good number of properties can be added to the concepts that are introduced in the calculus class. Thus student is in conditions of learning to do these constructions.

5. Theory

The adopted theory is the Ausubel - Novak- Gowin.

6. Principles

• The educational event includes five elements:
    Student: the one who learns.
    Professor: the one who teaches.
    Knowledge: the material to be studied.
    Context.
    Evaluation.
• The concepts are the regularities that we perceive in objects or events and they
    are represented by a label.
• Learning is the constructive integration of thinking, acting and feeling

• The meaningful learning requires:
    Predisposition of the student in order to learn meaningfully.
    Meaningful learning material.
    Previous relevant knowledge or "anchorage."
• The miss conceptions are resistant to the change.
• The previous knowledge conditions the acquisition of new concepts.
• The cognitive structure has a hierarchical order.
• The conceptual map allows analyzing how the student structures the acquired concepts.
• The clinical interview could reveal the structure of a specific or determined knowledge
    of a student.
• The production of the knowledge in a topic could be understand and
    analyzed by means of the heuristic UVE.
• The   tools mentioned would allow to organize and plan the instruction.
    If the evaluation puts repetition done from memory of manifesto it is because it is carrying a learning
    rote.
• The scientific formation and methodology permits the teacher to work on a high level of efficiency.
• To foment the work in interdisciplinary groups, with commitment, desires of teaching and disposition in order to understand feelings of students and classmates, will permit a stronger educational task.

7. Concepts

Numerical sequences, functions, numeric groups, real and natural numbers, limit of numerical sequences, absolute value. Geometric interpretation of successions and of the limit of a numerical sequence.

8. Registrations

Record of clinical interviews.

Questionnaire

• What do you understand for numerical sequence?
• Could you mention examples of the daily life?

- How you do represent graphically a numerical sequence?
- Based on this representation, could you give a definition of numerical sequence?
- Which groups take place in this definition?
- How could you classify the numerical sequences?
- What do you understand for limit, of a numerical sequence?
- Which concepts include the definition?
- Which relationship exists between them?
- Do all the successions have limit?
- Which properties allow to find the limit of a numerical sequence?
- Could you give a formal definition of a numerical sequence?
- Which utility do you see on the limits definition, which role does $N_{(\&)}$ play?
- How do you interpret graphically the limit of a numerical sequence?

9. Transformations

Analysis and interpretation of the clinical interviews. The transformation was achieved by taking the conceptual maps which were made unrecording the tapes.

Both the guide questionnaire utilized in the interviews and the conceptual maps carried out are annexed at the end of the work. Between them there is the guide map, made up by the authors of the work.

10. Knowledge claims

In all the interviews, pertinent concepts were identified. In some cases they were scarce and they didn't allow to complete correctly the required definitions. In other cases these concepts had not been assimilated correctly giving place to misconceptions.

In general, the students' answers were not very much related with the left part of the UVE. Although the student was apparently active, s/he didn't achieve, in most of the cases, to relate what s/he said with the right concepts.

Most of the mentioned examples included concepts wrongly used, for example:

a) they confused numerical sequences with numeric series.

b) The groups domain and codomain were not correctly identified.

c) The examples didn't represent numerical sequences.

The statements were in all the cases related to the graphic interpretation of the succession and numerical sequence limit concepts.

In most cases, the concepts that are in the definitions already mentioned remained absent in the construction of the map. In some cases the map was very poor, few concepts were included and they were not very well related.

The concepts of absolute value, arbitrary small magnitudes (épsilon), the $N_{(\&)}$ relationship, were neither understood nor bounded among them. There aren't any evidences left that determine the role that these concepts play in the correct definitions.

In many cases, to explain or attempt to clarify a not very familiar or confusing concept they appealed to expressions of the kind: "you explained it, "what you have already said," etc.

The longer the time from the end of the cause, the more lack of clarity and of capacity to relate concepts. The graphic interpretation of the definitions is, in these cases, only an outline of concepts expressed wrongly and tied with examples totally inappropriate.

11. Value Claims

1-The students' attitude was totally active, responsible and mature. All the interviewees, in spite of being freshman students, showed interest to cooperate and they worried about what they understood by themselves: lack of clarity in the concepts and ignorance in some cases. It is surprising in this aspect that the teacher stopped playing a fundamental role and the students themselves became, the responsible ones for this conduct.

2- All the interviewees thanked, saying that "the talk helped them to understand many things." Others hoped that this work would helps to diagnose the situation, to review the curricular contents and they manifested interest making suggestions, for example, to give more importance to the problems of application to engineering where specific successions like the arithmetic's and geometric's ones are often introduced.

3- All of them recognized that the definition of limit could not be very well understood in only one term. The students who attended the course twice said that they assimilated these concepts gradually during each course. They could obtain very little advantage from the formal definition of limit. They used the graphic interpretation in order to pass the tests.

4-Everything that was said deserves a deep reflection by the professor:

4.1-We may wonder that if the answers are of this type, is it valid all formalism and the severity demanded in this topic?

4.2-It is truth that the development of such topic contributes to fundamental concepts, but what happens if the student cannot relate them to his daily life experience?, What if they are not related to the rest of the subject and the level of abstraction and complexity requested make it impossible to understand the basic part?.

4.3-Perhaps we should work on adequate methodological aspects in order to deal with these

definitions: incorporating conceptual maps or interviews during the development of the topic. All these elements could contribute to the learning of this topic to be more meaningful and substantial, less mechanical.

4.4-Science changes, man requires a different handling of the tools of calculations, what was useful in the past and had an ethical and aesthetic value, does not have the same value these days. The approach of this topic in this Curricula of the career of Engineering deserves to be reconsidered and confronted with another commitment by the professor and the authorities that work in the organization of a career.

Analysis of the Result of the Clinical Interviews

Considering the results of the interviews we wonder:

Why these students, who have recently attended and passed Calculus cannot express their knowledge about the topic?

We could think that there is a multiplicity of factors that could be ordered in the following way:

a) Contextual Factors

• Type of career: in the curriculum of the career to which these students belong, mathematics and especially the investigated topic has an operational sense, in other words, it is used as basic tool without important implications in the future.
• High quantity of student
• Few teachers
Too long syllabuses for the time given to the term.

b) Conceptual Deficiencies

In this aspect we wonder which conceptual contents should the students have in order to learn Limit?

• Functions: definition and construction and graphic interpretation
• Numerous successions
• Intervals

The professor should not confuse these contents with the alternative, spontaneous or erroneous conceptions that the students could use in order to use formal definitions.

c) Previous Concepts

When the student is explained with a definition with high level of formality and abstraction which should be used to solve problems, it is possible that s/he won't be able to connect successfully the new knowledge with more general concepts of his cognitive structure that could act as subsumes [Ausubel, 1968].

When this occurs the student begins to utilize the rote learning as resource.

d) Metodological Aspects

The methodology used for the subject doesn't favor the meaningful learning but on the other hand contrary tends to develop a memoristic learning where the student should solve and operate mechanically by means of the application of a definition

e) Regularity Conditions of the Subject Matter

The student passes the subject with partial tests where the topic involved is tested by asking him to "try" using the definition or simple calculating the limit of a given function.. In both cases it is possible to get favorable result without understanding the concept.

Conclusion

Considering the previous question:

> Is it possible that the students, learn meaningfully, the concept of limit?

We believe that, whenever you keep in mind the following conditions:

1. That the student takes on the commitment of learning calculus from a wider optic, which won't consider it as mere operational tool.

2. That the professor keeps in mind the previous concepts of the students, the conceptual necessary contents in order to undertake the topic and if necessary using previous organizers as a bridge between what the student knows what and s/he which needs to knows and what s/he needs in order to learn the concept of limit meaningfully.

3. That the material used is potentially meaningful, in other words:
clear, [plausible] and non arbitrary, or as Ausubel himself says" that it has a logical meaning or internal logic and real or psychological meaning."
We can appreciate that it is possible to improve the learning of topics like that analyzed at university level, but this requires commitment and effort from the students and professor, flexibility of

the themes and the acceptance that there are pedagogic problems and the possible search of solutions.

BIBLIOGRAFY

Ausubel, D., Novak, J.D., and Hanesian, H. "Educational Psychology, a cognitive view". 2nd Edition (Holt, Rinehart and Wiston, New York, 1978).

Ausubel, D., Novak, J.D., and Hanesian, H. "Psicología educativa. Un punto de vista cognoscitivo". 2a Edición. (Trillas, México, 1983)

Bloom, B.S. "Human characteristic and school learning" (McGraw Hill, New York, 1976)

Chrobak, R. (1997a) An Instructional Model for the Teaching of Physics, Based on a Meaningful Learning Theory and Class Experiences -1997- Publicado en la revista de Internet, (Vol 2, Nº 2) : "Investigation in Science Education", Univerdidade Federal do Rio Grande do Sul, Instituto de Física, Porto Alegre, Brasil.

Chrobak, R. (1997b) Meaningful Learning in Graduate Courses -1997 - Presentado oralmente y publicado en memorias del "International Meeting on Meaningful Learning" Realizado en la Universidad de Burgos, España, en setiembre de 1997, ciudad de Burgos.

Chrobak, Ricardo (1997c) "Methodology of Teaching of Sciences" (Material utilized in him modulates of the same name). Master in Teaching from the Exact and Natural Sciences.

Chrobak, R. (1996a) El nuevo rol del sistema educativo en la transferencia de tecnología en ciencia de matreriales Presentación en poster y publicación en actas la Reunión NOTIMAT 96 a realizarse en el Centro Atómico Bariloche, el 24 y 25 octubre de 1996, en San Carlos de Bariloche. (En coautoría con Julio Vivas Hohl y Jorge Fisina)

Chrobak, R., Herrera, C. (1996b) "Experiencia piloto para el desarrollo de un nuevo modelo instruccional" Revista Brasileira de Ensino de Física, Vol. 18, Nro 2, pp. 122-136.

Chrobak, R. (1996c) Un modelo científico de instrucción, para enseñanza de Física, basado en una teoría comprensible del aprendizaje humano y en experiencias de clase. Memorias de la "III Escuela Latinoamericana sobre investigación en Enseñanza de la Física", realizada en Canela, Brasil.

Chrobak, R. (1996d) La Enseñanza de Ingeniería en el siglo XXI. Memorias del "Primer Congreso Argentino de Enseñanza de ingeniería", realizado por La Universidad Nacional de Río IV, provincia de Córdoba, del 7 al 11 de octubre de 1996.

Chrobak, R. (1995a) "Uso de estrategias facilitadoras del aprendizaje significativo en los cursos de Física introductoria". Revista de Enseñanza de la Física. Editada por la Asociación de Profesores de Física de la Argentina (APFA) -

Volumen 8 - Nº 1 - pp. 7-21.

Chrobak, R. (1995b) El perfil del ingeniero para el siglo XXI en Latinoamérica Presentación al Congreso de Materiales en Bariloche. (Coautores: Jorge Fiscina y Julio Vivas Hohl)

Chrobak, R. (1995c) Una Verdadera Reforma para la Enseñanza de la Física Presentado oralmente y publicado en memorias de la "Novena reunión de enseñanza de Física" Realizada en la Universidad Nacional de Salta, setiembre de 1995, ciudad de Salta.

Chrobak, R. (1993a) "Metodología para un Aprendizaje Significativo" Cuadernos Universitarios. Universidad Nacional del Comahue, Facultad de Ingeniería, Departamento de Física.

Chrobak, R. (1993b) "Análisis de las opiniones de los estudiantes sobre la Enseñanza de Cursos Introductorios de Física" Actas del Primer Congreso Nacional sobre Problemática de la Enseñanza de la Física en Carreras de Ingeniería, Instancia Final, Paraná, Entre Ríos.

Chrobak, R. (1992) "Learning how to teach Introductory Physics Courses" Master's Thesis, Cornell University, Ithaca, New York.

Gowin, D.B. (1981) "Educating" (Cornell University Press, 1981) Ithaca, New York

Glaserfeld, E von (1989). Cognition, construction of knowledge and teaching. Synthese, 80, 121-140.

Hestenes, D., Malcolm, W., & Gregg, S. "Force Concept Inventory". The Physics Teacher, Vol. 30, March 1992; p. 141-166.

Holcomb, D.F. (1978) Teaching Introductory Physics to Students in Engineering and Science at Cornell. Ithaca, N.Y. Unpublished manuscript.

Johnson, Mauritz, Jr. 1967 "Definitions and Models in Curriculum Theory". Educational Theory, 17(2), 127-140

Laine Gurley, (1982) Use of Gowin's Vee and Concept Mapping Strategies To Teach Students Responsibility for Learning in High School Biological Sciences. PhD dissertation, Cornell University.

Mager, R. F. "Preparing Objectives for Programmed Instruction", Fearon, San Francisco, 1962.

Moreira, M.A. "An Ausubelian Approach to Physics Instruction: An Experiment in an Introductory College Course in Electromagnetism" PhD Thesis (Cornell University, N.Y. Ithaca, 1977)

Moreira, M.A. "Uma abordagem Cognitivista ao Ensino da Física", Porto Alegre, Brasil, Editora da Universidade, 1983

Moreira, Marco A. y Buchweitz, Bernardo, "Novas estratégias de ensino e aprendizagem" (Gabinete Técnico de Plátano Editora, Lisboa, 1993)

Moreira, M. A. y Silveira, F.L., "Istrumento de Pesquisa em Ensino & Aprendizagem" (edipucrs, Porto Alegre, Brasil, 1993)

Moreira, Antonio (1995) Frame "The Theory

of the Meaningful Learning of Ausubel". Monografias of the Group of Teaching. Series Focuses Theoretical Nro. 10.

Novak, J. D. , "A Theory of Education" (Cornell University Press, Ithaca, N.Y. 1977). En español: "Teoría y Práctica de la Educación" (Alianza Editorial, Madrid, 1982)

Novak, J.D. & Gowin, D.B. "Learning How to Learn" (Cambridge University Press, N.Y., 1986)

Novak, J.D. & Gowin, D.B. "Aprendiendo a aprender" (Martínez Roca, Barcelona, 1988)

Rinaudo, Maria Cristina (1997) "Psicologic Theory of the Learning" (Material used in the modulates of the same name). Master in teaching. from the Exact and Natural Sciences