Innovating with Concept Mapping
Proc. of the Seventh Int. Conference on Concept Mapping
Tallinn, Estonia 2016

TEACHING EXPERIMENTAL SCIENCES USING CMAPTOOLS SOFTWARE FOR THE DESIGN OF KNOWLEDGE MODELS IN THE DEGREE OF PRIMARY EDUCATION TEACHING (DPET)

Maider Pérez de Villarreal & Fermín González, Universidad Pública de Navarra, Spain
Email: maider.perezdevillarreal@unavarra.es

Abstract. Experimental Sciences teaching corresponds to a broad area containing some of the core subjects of the Degrees of Infant and Primary Education Teaching at the Public University of Navarra. It belongs to the Teaching module and discipline and to the field of "Knowledge of the natural, social environment and its teaching", that is mandatory and consists of a total of 24 ECTS, of which 6 ECTS correspond to "Teaching of Natural Sciences" (TNS). This course is taught in the second half of the second year of the DPET. The aim of this work has been the preparation of this course as a Knowledge Model (KM) including several Concept Maps (CCMM) with different levels of deepness of the developed topics; and to check if this new way of presentation has a positive effect on students' satisfaction towards the teaching and the learning process (TLP) and if they see more meaning and coherence to the use of concept maps for learning if they are shown the complete course in "this significant language". Results show although it is difficult to change from the comfort zone at the beginning, when students start using CmapTools for creating their own Knowledge Models, they finish learning meaningfully and understanding better the whole course, find it easier to study for the evaluation and get to the domain of Knowledge by reaching basic, general and specific skills.

1 Introduction

The current educational landscape is undergoing a change not only in methodologies, teaching styles and teaching methods, but in terms of resources provided by technology. In 2001, González et al., warned the current context required a shift from the predominant positive-behaviorist model that favored mechanical rote learning, which was an ideal breeding ground for the generation of misconceptions (González, Morón & Novak, 2001), towards another cognitive-constructivist, which would stimulate meaningful learning. This new paradigm would allow students to build and master knowledge, therefore becoming more creative and critical (Meichembaum & Biemiller, 1998). In this century, we face a number of challenges: some come from the so-called society of knowledge and information, which can be summarized in a change of an ethic of obligation for another of responsibility, widespread use of information and communication technologies, the so called ICT, and the requirement of a school, in generic terms, of quality, accountable to society and which encourages students to get universal literacy, motivation to learn and discipline for long life learning. Others come from the implementation of the European High Education Area (EHEA) which implies a change in the model of teaching / learning, shaping a new role not only for teachers, but also for students, and affects the redesign of the subjects contained in the called Teachers' Guides (Zabalza, 2004). In this new paradigm, students play an active role not only learning about the product but through the process itself (metacognition). The teacher's responsibility is primarily to create conditions that facilitate students the ability to transform information in useful, substantive and transparent knowledge, which is incorporated and well-articulated in their long-term memory.

The assessment in this new educational scenario, plays a key role in promoting continuous improvement, consolidating the strengths and correcting weaknesses. Such evaluation should take two dimensions (Novak, 1998): first measure what students know and secondly, assess how their cognitive structure has changed in relation to such knowledge, by evaluating the necessary conceptual change (Posner, Strike, Hewson & Gertzog, 1982). It is noteworthy in this model, the teaching dimension (emphasis on teaching or what is taught) is subordinated to what it is learnt and how students learn better and get skills for their future. Under this focus, the teaching-learning process (TLP) changes into the learning-teaching process (LTP). That is to say, education is a concept based in learning and student-centered. Primary and Secondary Schools as well as Universities have to use their potential in order to promote teaching/learning quality, define adequate learning results and point the way to get them (Pérez de Villarreal, 2015).

The theoretical framework of Ausubel, Novak and Gowin is suited as well as their methodological application through the construction of Concept Maps (CCMM) and Gowin's epistemological "Vee" diagram. CCMM and Vee diagrams are metacognitive tools which help enhancing the conceptual change nowadays needed in the way of educating in knowledge. In the 80's, Ausubel developed his theory of meaningful learning remarking that: the student must demonstrate a willingness to relate substantial and not arbitrarily the new material in his cognitive structure, as the learning material is potentially significant for him; this is, relatable with his knowledge structure on a non-arbitrary basis (Ausubel, 1983). Substantial and not arbitrary relationship, should be understood in the way that the ideas relate to an existing specifically relevant aspect of the cognitive structure of the student, as an image, a significant symbol, a concept or proposition. This means that in the educational process, it is important to consider what the individual already knows, so that he can establish a relationship with what he must learn.

This process takes place if the student has in his cognitive structure concepts, such as the following: stable and defined ideas and propositions, with which new information can interact. The Vee heuristic technique was invented by Gowin (1981) as a strategy to solve a problem or to understand a procedure and could be applied in basic and secondary education and university. Gowin proposed the Vee diagram as a tool to be used to critically analyze a research, understand an experiment in the laboratory, as a teaching method for promoting meaningful learning and elicit knowledge. According to Guardian and Ballester (2011), Gowin's Vee is a heuristic and metacognitive technique that illustrates and facilitates learning through theoretical and methodological elements that interact in the process of building knowledge for solving a problem. Therefore, the Vee is considered a technique used to learn to learn (and think). This is a diagram in a V, which is represented visually as a knowledge structure. Knowledge refers to objects and events in the world. We learn something about it when posing questions under concepts organized into sets of principles (which explain how objects and phenomena behave) and theories, from which we can plan actions (experiments) that will lead us to answer the initial question.

Novak (1982) shows that CCMM and Vee diagrams positively influence teaching, learning, curriculum and environment, and these four elements, along with the feelings and actions, become part of any meaningful educational experience.

The Vee diagram was designed as a heuristic tool that interrelates the knowledge, know-how and knowledge to be; for example, the contents related to concepts, procedures and attitudes (scientific competences); and also allows integrating everyday knowledge with scientific knowledge, being considered highly significant. (Ausubel, Novak & Hanesian, 1983; Novak & Gowin, 1988; Barriga & Hernandez, 1999; Sánchez, 1999; Ontoria, 2001).

Authors such as Anta (2001), have conducted research related to the usefulness of the schemes and specifically of Vee diagrams in different disciplines, educational levels and national and international academic spaces. All agree on the usefulness of this tool for the meta-cognitive development of students.

The five original questions proposed by Gowin (1981) to apply to any statement or document in which some knowledge is present are: i) Which is the decisive question?, ii) Which are the key concepts?; iii) Which are the research methods used ?; iv) Which are the main statements about knowledge? and v) Which are the main value judgments?

These five questions summarize the construction of knowledge, for understanding to solve the posed problem. The model has been adapted to different sciences and areas of knowledge for its effect on the production of meaningful learning; one of the most important models were applied by Moreira (2006) in Brazil, with considerable success. In some of his articles, he shows the application of the Vee, especially in problem solving activities in secondary and university education.

For Moreira (2006), meaningful learning is a process through which the same information relates, in a non-arbitrary and substantive manner, with an important aspect of the cognitive structure of the individual. Thus, meaningful learning is characterized by interaction, and not a simple association between specific and relevant aspects of the cognitive structure and new information. Meaningful learning involves questioning and requires the personal involvement of the learner; this is, a reflexive attitude towards the process itself and the content learning object, tending to ask ourselves what we want to learn, why and why significantly learn it (Moreira, 2010). Thus arises a new contribution, which is its criticality. Through critical meaningful learning it is how students can be part of their culture and at the same time not be subjugated by it, by its rites, myths and ideologies. (Moreira, 2005: 88).

For Gowin (1981), meaningful learning takes into account the important influence of emotional experience in the process leading to its development. But it is not just a result, but a process in which meanings are shared; this idea is widely developed in the postulated educational theory. For him, "teaching is consumed, when the meaning of the instructional material the student grasps, becomes the meaning that the teacher intended that this material should have for the student." (Gowin, 1981). The essential contribution of Gowin, is the establishment of a triadic interaction between teacher / student / educational curriculum materials aimed at sharing meanings, without which, in any way, meaningful learning (Rodríguez, Caballero & Moreira, 2010) would be obtained. In addition, Gowin defines the responsibilities of the different actors in the process of learning; for example, the educational curriculum materials, should follow some pedagogical and didactic orientations (Zufiaurre & Belletich, 2014; Pérez de Villarreal & Belletich, 2015; Belletich, Pérez de Villarreal & Zufiaurre, 2013), which show the importance of the design and programming of educational processes, clearly explained in the Instructional Design Theory, considering particularly important the design approach in science education. According to Godino *et al*., (2013), the learning research based in design (design research or design of experiments) is part of a family of methodological approaches, that takes place in the natural context of a class. It uses systematically design, analysis tools and instructional strategies. Thus, the research includes, in successive cycles, both the design and implementation in the context of a class and the evaluation of the results. In this theory, three main elements may be considered in all teaching sequence: planning (programming), execution (activities) and assessment (acquisition of skills or competencies). Also, other research studies (González, 2008; González, Morón & Novak, 2001; Novak, 1998) show wide evidence, demonstrating the great potential of CCMM to improve teaching, both for the diagnosis of students' prior knowledge and for the design and implementation of consistent curriculum and instruction by the teacher. The three components of the Instructional Design Theory should be included, all under the perspective of the objectives: Programming (prior organization of the number of weeks provided for theoretical instruction and the number of weeks aimed at practical sessions in the spring semester); Execution (activities to develop: initial, processing and summary); Assessment (skills developed in each activity).

Since we wanted our students to start using this methodology, we considered we should provide the information in a consistent manner with what was being taught; in this case, the course of TNS which corresponds to the second semester of the second year of the DPET at the PUN.

2 Material and Methodology

2.1 Design of the subject TNS

In this study, we aimed to implement a new system of course presentation forwarded to students of the DPET, centered in the subject "Teaching of Natural Sciences" (TNS). This subject belongs to a broader area, "Teaching Experimental Sciences" and specifically to the field of "Knowledge of the natural, social environment and its teaching". TNS is compulsory in the curriculum of the PUN, and consists of a total of 6 ECTS (European Credit Transfer System) from a total of 24 ECTS (in the whole area). It develops the following topics:

- Teaching and learning sciences today.
- Science and modeling.
- Physical systems.
- Matter and its changes.
- Living things and their environment.
- The human body.
- School scientific activity: key ideas, curriculum, previous ideas of students and media for their evolution.
- Resources for teaching Studies: field trips, ICT and laboratory.
- Fundamentals and the application of the scientific method in teaching and learning about the natural environment.
- Theory to design environmental exploration projects.
- Inquiry learning.
- Guidelines for preparing proposals and integrated educational projects based on the Natural Environmental Knowledge (NEK) area which are called Instructional Modules (IM).

TNS subject was developed according to the Curriculum of Primary Education in Navarra (Spain) and aims to expand and deepen the content and necessary skills to teach the subject "Natural Environmental Knowledge" (NEK), which is compulsory in the three cycles (each cycle comprises two courses) of Primary Education. In TNS, students will work specially on scientific ideas they will develop in NEK in Primary Education ("content of school science"), and how to approach the teaching and learning process (TLP) by promoting constructive and inquiry activities. Some of these activities integrate the use of Information Communication and Technology (ICT) Tools, such as CmapTools software (Cañas *et al*, 2004) from IHMC (Institute for Human Machine and Cognition, Florida, USA) for their use in the social construction of knowledge.

2.2 Objectives of TNS:

The objectives of the TNS course are:

- To identify and discuss the contents of basic school science and the key ideas developed in Primary Education.
- To deepen the perspective of teaching and learning in school science activities that integrate the construction, inquiry, research and communication.
- To know, propose and evaluate activities for the development of scientific competence in Primary Education.

2.3 Skills

The skills students have to acquire at the end of the course are the following:
Basic skills (BS):
BS1 - That the students have demonstrated knowledge and understanding in a field of study that part of the basis of general secondary education, and is typically at a level which, although it is supported by advanced textbooks, includes some aspects involving knowledge of the forefront of their field of study.
BS2 - That the students can apply their knowledge to their work or vocation in a professional manner and have competences typically demonstrated through devising and defending arguments and solving problems within their field of study.
BS3 - That students have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical issues.
BS5 - That students have developed those skills needed to undertake further studies with a high degree of autonomy.
General skills (GS):
GS1 – To know the curricular areas of Primary Education, the interdisciplinary relationship between them, the evaluation criteria and the body of didactic knowledge regarding the respective teaching procedures and learning.
GS2 – To design, plan and evaluate teaching and learning processes, both individually and in collaboration with other teachers and school professionals.
GS7 – To collaborate with different sectors of the educational community and the social environment, assuming the educational dimension of the teaching profession and promoting democratic education for active citizenship.
GS8 – To maintain a critical and autonomous relationship with respect to knowledge, values and public and private social institutions.
GS9 – To assess individual and collective responsibility in achieving a sustainable future.
GS10 – To reflect on classroom practices, to innovate and improve teaching, acquiring habits and skills for independent and cooperative learning and promoting it among students.
GS12 – To understand the role, possibilities and limits of education in today's society and the core competencies affecting Primary Education schools and its professionals. To get to know models of quality improvement with application to schools.
Transversal competences (TC):
TC2 – To demonstrate proficiency in Spanish and, where appropriate, in Basque equivalent to level C1 of the "Common European Framework of Reference for Languages: learning, teaching, assessment" of the Council of Europe.
Specific competences (SC):
CE1 – To know the objectives, curriculum content, the meaning of the areas and the organization, methodology and criteria for the assessment in Primary Education.
CE2 – To design, plan and evaluate teaching and learning in response to interdisciplinary and disciplinary criteria with other professionals.
EC7 – To promote cooperation, motivation and desire to learn, and actively participate in school projects.
EC9 – To acquire habits and skills for autonomous and cooperative learning to promote the active involvement of students in their social and personal development.
CE10 – To reflect regarding classroom practices to innovate and improve teaching, and refer to the operation of the basic psychological processes, pedagogical models and disciplinary criteria of the stage.
CE12 – To actively organize the teaching and learning of the contents of Primary Education from the perspective of skills development. To get to know models of improvement quality.
CE14 – To contextualize the teaching action in the political, social, and pedagogical changes, fostering democratic education and development of active citizenship for achieving a sustainable future.

2.4 The structure of TNS in the didactic guide of the Public University of Navarra (PUN)

This course consists of 6 ECTS which correspond to 150 hours/ work for the student, of them, 40% (60 hours) belong to classroom and lab teaching (with theoretical and practical sessions) and 60% (90 hours), to personal study. TNS caters to the teaching sequence consisting of: Programming, Implementation and Evaluation.

2.4.1 Programming and organization:

The number of hours aimed at teaching, are spread over 15 weeks, leaving the last week for the presentation of the IM, in which the students (in groups of 4-5) have to develop a selected topic contained in any of the 5 blocks of the area of Natural Sciences, inside the Curriculum of Primary Education in Navarra (see BON, number 174, September 2014, pp. 7-16).

2.4.2 Implementation

- *Structure of the theoretical and practical content:*

The agenda is structured in three blocks, taking into account the philosophy (cognitive / constructivist) underlying the approach of the subject. Firstly, Block I was designed to lay the theoretical foundations that allow students to learn meaningfully and build knowledge (through research related processes), to provide them with the appropriate tools to carry out these tasks. Also, in Block II, it is intended that the students learn the curriculum of primary education, with regard to Environmental Awareness and applied in Navarra (Spain). In Block III, all theoretical and practical knowledge acquired in Block I, is used for the development of the IM based on a selected block of the Natural Science curriculum, evidencing the knowledge acquired by the students and their domain, which is shown through public presentation of the model.

BLOCK I:

Item 1: Analysis of educational models: traditional (behaviorist, positivist) and progressive (cognitive and constructivist)

1.1. Theories of teaching / learning of Ausubel, Novak and Gowin, for the teaching of natural sciences

1.2. Fundamental principles thereof

1.3. Theory of conceptual errors

Item 2: Instructional Techniques for improving the teaching-learning environment

2.1. Concept maps and meaningful learning of the natural environment

2.2. The UVE knowledge, meaningful learning environment, building knowledge and research process of the natural environment

BLOCK II:

Item 3: Curriculum of Primary Education in Navarra (Spain). Science: objectives, content and evaluation criteria

3.1. Learn about physical systems in primary education. What are the key ideas? What does the curriculum say? What previous ideas do students have? How can we evolve?

3.2. Learning about matter and its changes in primary education. What are the key ideas? What does the curriculum say? What previous ideas have the student? How can we evolve?

3.3. Learn about living things and their environment in primary education. What are the key ideas? What does the curriculum say? What are the previous ideas students have? How can we evolve?

3.4. Learn about the human body in Primary Education. What are the key ideas? What does the curriculum say? What are the previous ideas students have? How can we evolve?

BLOCK III:

Item 4: Development of a curriculum and instructional design regarding selected aspects of Experimental Sciences

4.1. Guidelines for the development of a curriculum and instructional design in relation to the Natural Environment

4.2. Developing the corresponding knowledge

4.3. Public presentation of the Instructional Module (IM)

- *The teaching methods* used are:

- Masterly exhibition (purely theoretical content) in large group (44 students). In this sessions, the teacher raises previous ideas concerning the particular issue to address in order to detect students' prior knowledge; then, she leaves a time (about 20 minutes) for students to comment and discuss between them. After this time, they put in common and the teacher comments the concept maps or presentations referred to the particular issue, in order to solve any questions that will arise students, avoid misconceptions and at the same time, refresh prior knowledge.
- Practical and laboratory exercises in medium groups (24 students in one medium group and 20 in the other). For the development of the practical training, students are gathered in small groups of 4-6 individuals, which are held throughout the semester, managing themselves and distributing the work to be done. In this sessions, students perform practical exercises related to theoretical contents, or where appropriate, develop laboratory experiments, perform dramatizations, write reflections on the research method or methodologies, read research articles, play trivial based on TNS contents, and finally publicly expose their Instructional Module (IM).
- Face tutorials: they are designed to answer questions and establish guidelines and tasks for self-study.

2.4.3 Assessment

ASSESSMENT	% OF VALUE COMPARED TO WHOLE COURSE	RETRIEVABLE (%)
Asistance and participation	10	0
theoretical work, practical exercises, reviews, synthesis	20	15
Instructional Module (containing KM)	30	15
Oral or written tests	40	40
TOTAL	100%	70%

Table 1: Table showing TNS Assessment

2.5 Vee diagram

In order to clarify the structure and design of the course, a Vee diagram was developed so that we could contemplate the steps to follow and it could serve as a guide for obtaining the initial goals (see 2.1).

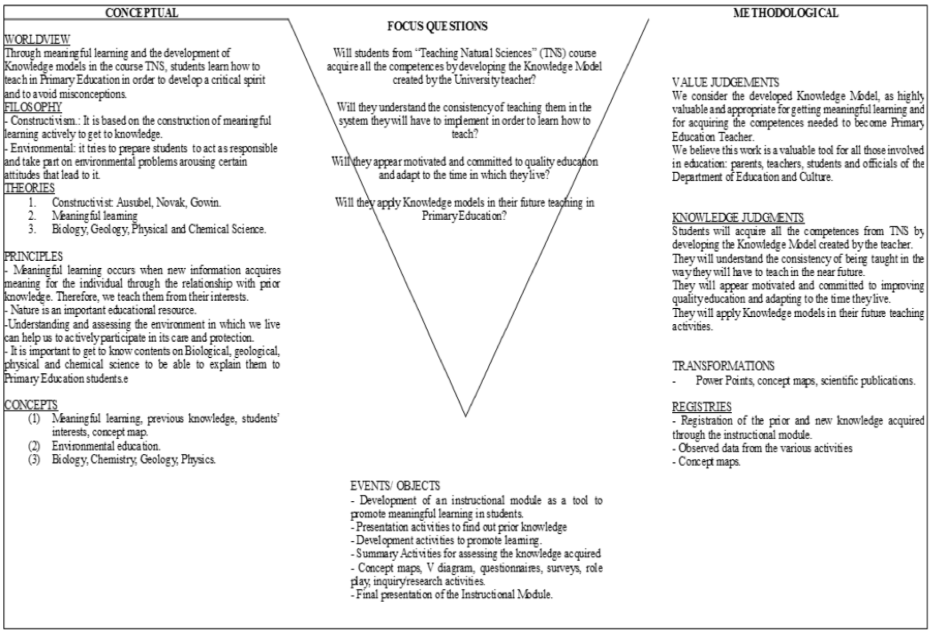

Figure 1. Vee diagram of the TNS course with the focus questions highlighting the objectives of the work.

As mentioned in the introduction, Gowin (1981) developed this heuristic tool which incorporates 12 elements for the process of knowledge construction, including not only the steps of the scientific method, but also the conceptual knowledge represented on the left of the Vee, including the world view, philosophy, theories, principles and concepts, guiding the research. The Vee diagram (González, 2008) is a method which can help students and educators to analyze the structure and meaning of the knowledge they try to understand (metacognition) and allows the incorporation of new knowledge to the cognitive structure the student already has transforming the learning process into a meaningful one. The shape of "V", is not an accident, but it was designed to house on the left side the conceptual / theoretical (thinking) part, and on the right side, the methodological / practical (doing) part, both directed to refer to objects and events in the process of knowledge production.

The V diagram (Figure 1) has been designed in order to answer the following focus questions which represent the objectives of this work and to serve as a guide for the teacher throughout the whole teaching / learning process:

- Will students from "Teaching Natural Sciences" (TNS) course acquire all the competences for becoming Primary Education Science Teachers, by developing the Knowledge Model created by the University teacher?

- Will they understand the consistency of teaching them in the system they will have to implement as future teachers (constructivism), in order to learn how to teach and avoid the positivist or behaviorist didactic style in which they were taught?

- Will they appear motivated and committed to quality education and continue their “long life training”, adapting to the time in which they live and leaving the comfort zone of repeating merely transmissive models and reception learning?

- Will they apply Instructional Modules (IM), which contain Knowledge Models (KM), in their future, for creating their own teaching material conceptually transparent when becoming Primary Education Teachers?

2.6 Inquiry

An inquiry was designed for students to check the usefulness of the presentation of TNS course (as a Knowledge Model using CmapTools software) and if it helped to answer the focus questions of the Vee diagram, which are really the goal of this work. This survey was answered anonymously by the students attending class in a particular day (30 students).

3 Results

3.1 Development of a Knowledge Model (KM)

The aim of this work has been the preparation of this course as a KM, including several Concept Maps (CCMM) with different levels of deepness of the developed natural science topics throughout the course of TNS.

A KM consists of a set of CCMM and digitized resources associated therewith, all in relation to a particular topic, in our case, related to TNS. It can also be defined as a collection of CCMM linked to a root map representing increasing levels of specific differentiation. Where appropriate, associated resources (photos, documents, videos, etc.) that are designated generically with graphical icons, are linked to the maps’ concepts.

In general, CCMM can be defined as diagrams which indicate the relationships among key concepts or nouns and it is a technique proposed and developed by Joseph Novak (Novak and Gowin, 1988). The relationships are shown by linking words which are normally verbs, adverbs or prepositions, that make a whole sense to the sentence created when linking concepts, which is called proposition. CCMM are powerful tools for describing structures of disciplinary knowledge through conceptual hierarchies or meanings, from general to more specific rules and they are dynamic creatures which evolve together with the knowledge of the student. It represents clearly as if it were a mirror, the cognitive structure of an individual; so it means, it is different in each one.

Graphic icons linked to concepts of the CM can be displayed by clicking on them and then on the writing that appears. Information shall be so displayed in the interface. The original map with the associated resources can be accessed via CmapTools (Cañas *et al*, 2004; Novak & Cañas, 2006).

Subordinated CCMM allow the user, to navigate through this model. KMs are useful tools to create meaningful learning and avoid conceptual misconceptions by means of the elaboration of CCMM and for their construction.

In the following figure, we show the root map of the KM of the course “Teaching Natural Science (TNS)”.

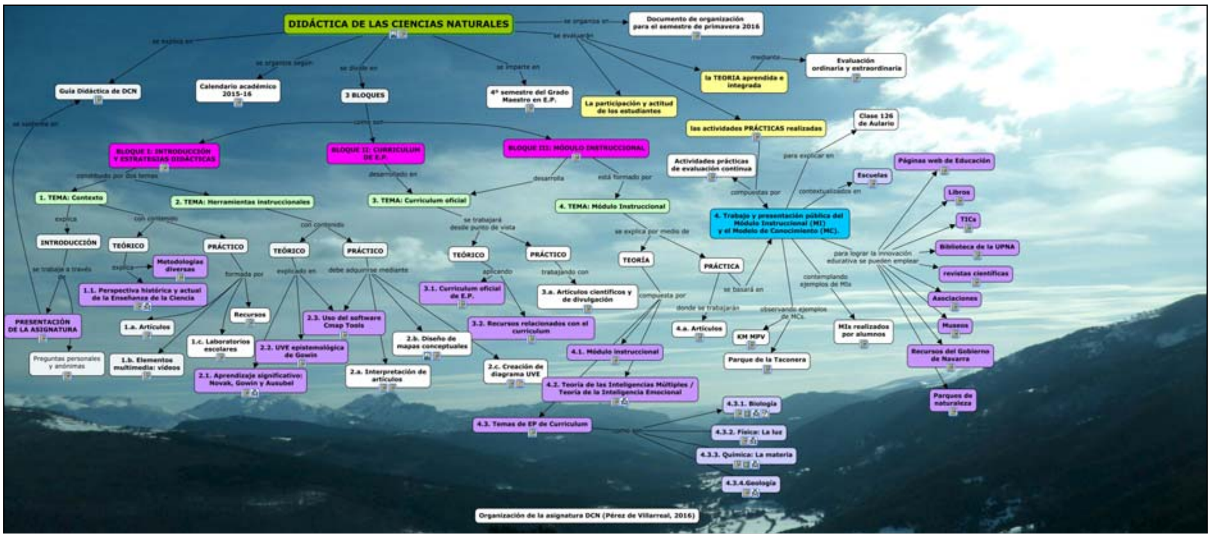

Figure 2. KM of the course "Teaching Natural Science" which contains all the links and resources associated, students have access to. Available at: http://cmap.unavarra.es/rid=1PSMC7T5F-18M53PG-2XD/DCN%20MPV.cmap.

From this root map we can have access to all the theoretical and practical content of TNS course. The map is structured in the same way as the teaching guide, containing three blocks with the correspondent theoretical and practical content.

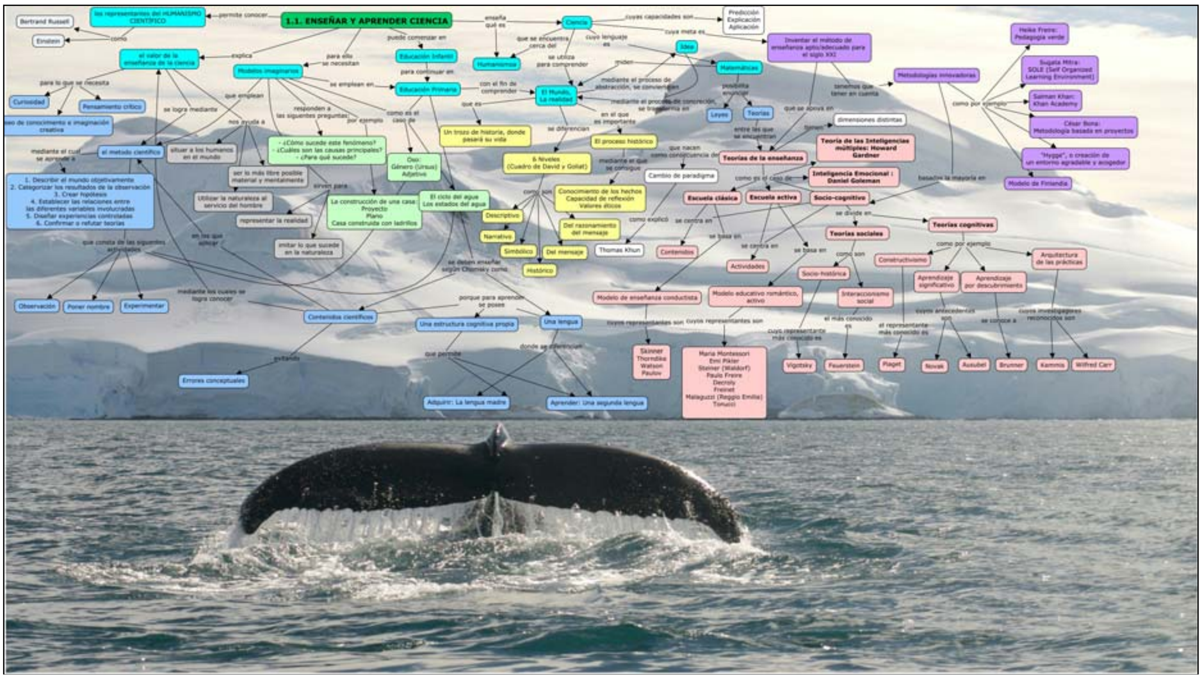

Figure 3. CM of the first theoretical topic of the first Block of: "Teaching and Learning Science" course.

This is the first CM showing the theoretical content of the first topic of the first block. In general, it summarizes part of the theories underlying TNS. It contains videos and research articles as well.

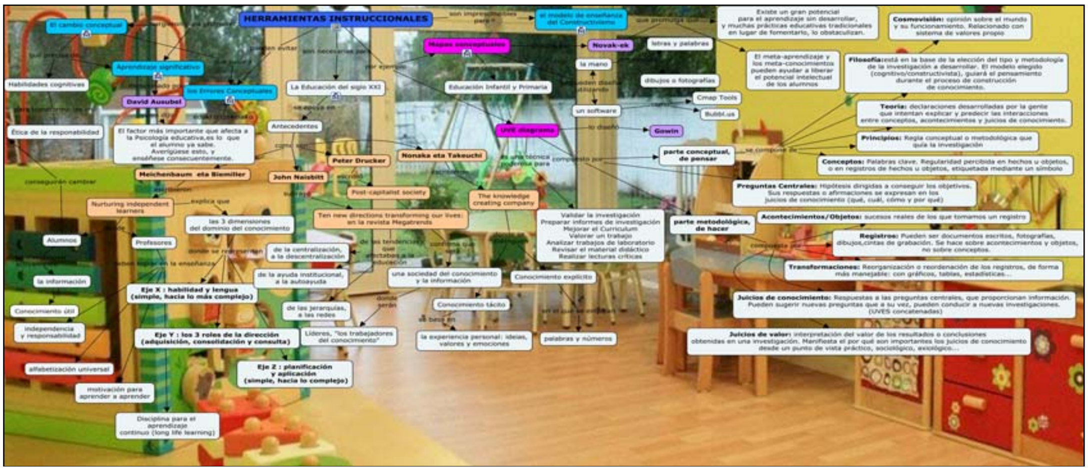

Figure 4. CM of the second theoretical topic of the first Block: "Instructional tools", which contains links to other submaps.

By means of this CM, we show the usefulness of the heuristic tools in TNS. Not only Vee diagram is explained, but also, the design of concept maps for the preparation of transparent and substantial teaching material.

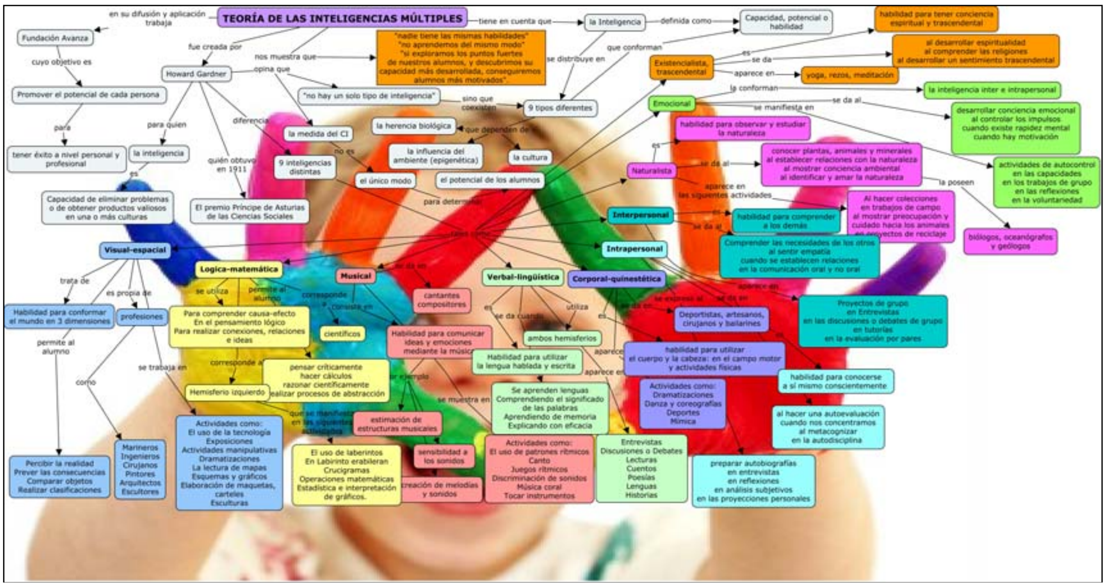

Figure 5. CM of a transversal theoretical topic related to the second Block: "Theory of Multiple Intelligences" to highlight the importance of developing teaching strategies taking into account the emotions, interests and abilities of students.

In both maps (Figure 5 and 6) we show both theories related to the abilities of human beings and to the consideration Intelligence is not only a matter of IQ (Intelligence Quotient); in the one side, the Theory of Multiple Intelligences developed by Howard Gardner (1983), and in the other side, the Emotional Intelligence, by Daniel Goleman (1996). Both theories, although different, agree on the idea of the importance of managing emotions, not only for learning, but for personal and professional development of the individuals.

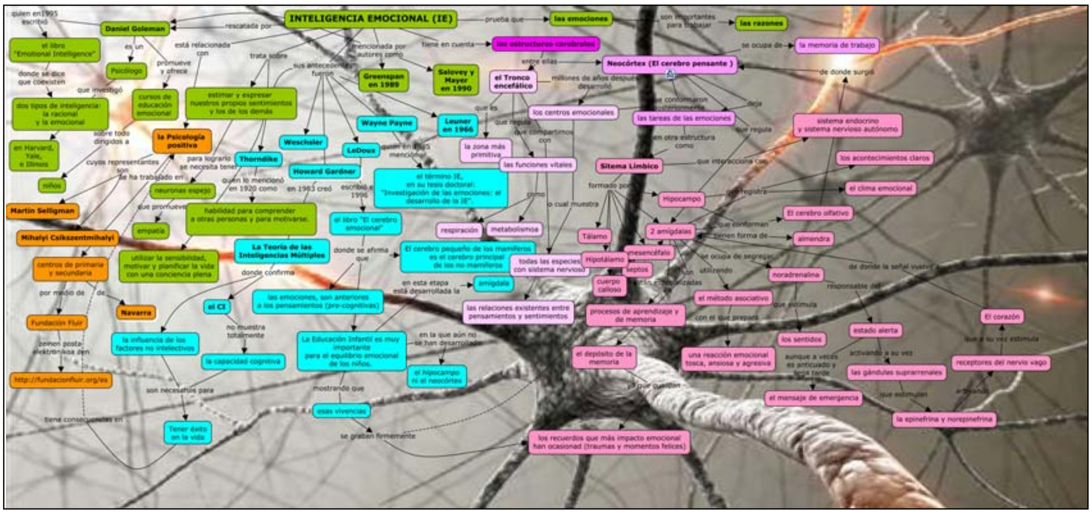

Figure 6. CM of a transversal theoretical topic related to the second Block: "Emotional Intelligence" inspired in Daniel Golemans's work and which also adds submaps.

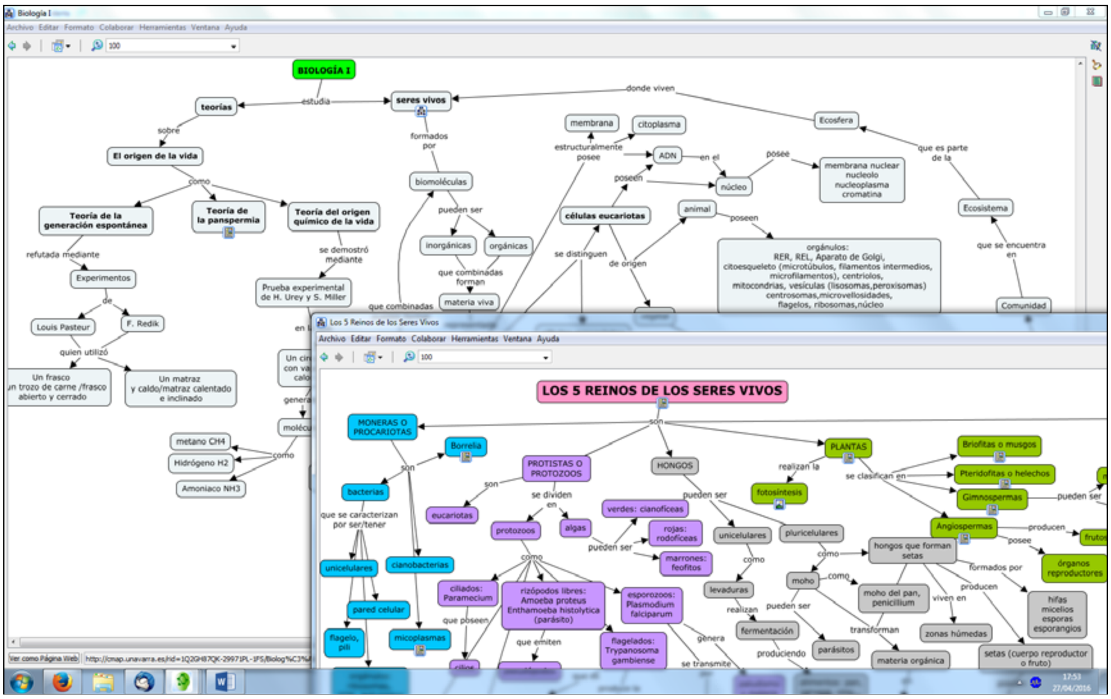

Figure 7. CM of the Biology contents to refresh previous ideas to TNS students.

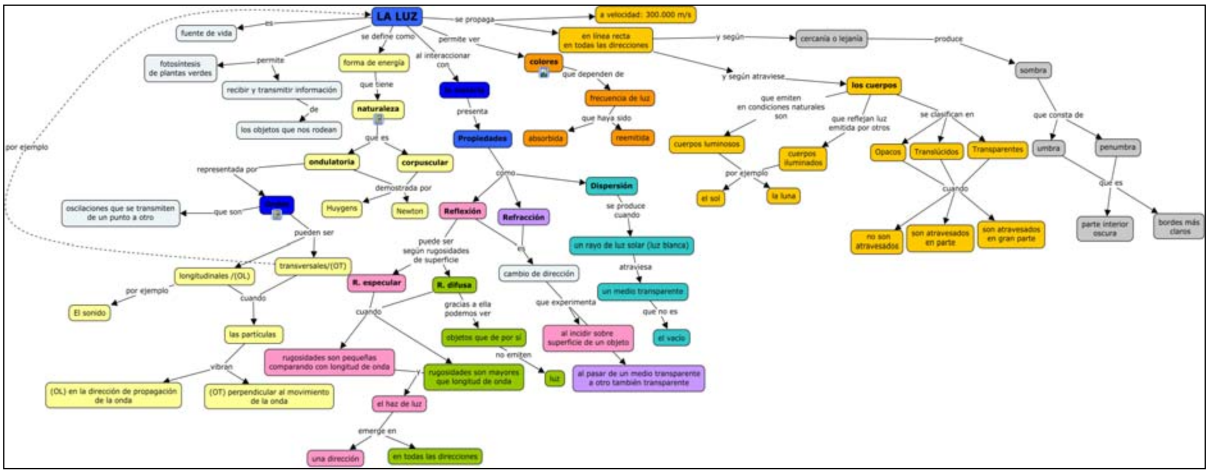

Figure 8. CM of Physical contents on the topic “The nature of light”.

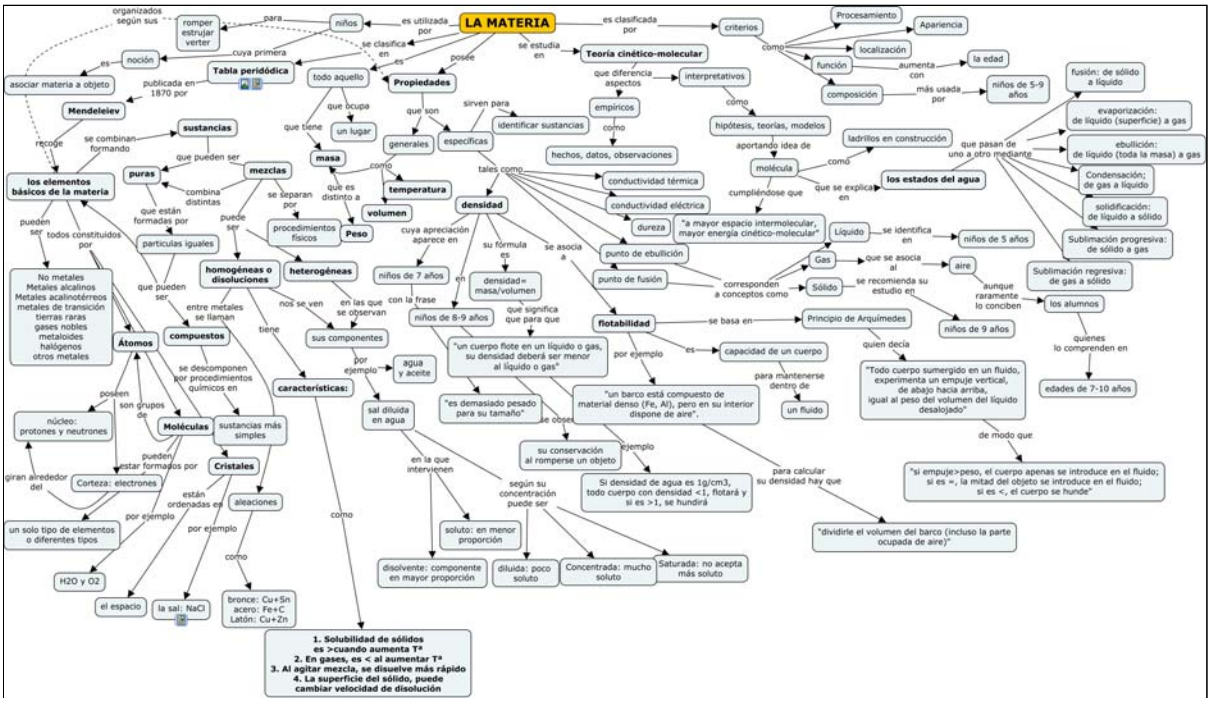

Figure 9. CM of Chemical contents on the topic “The matter”.

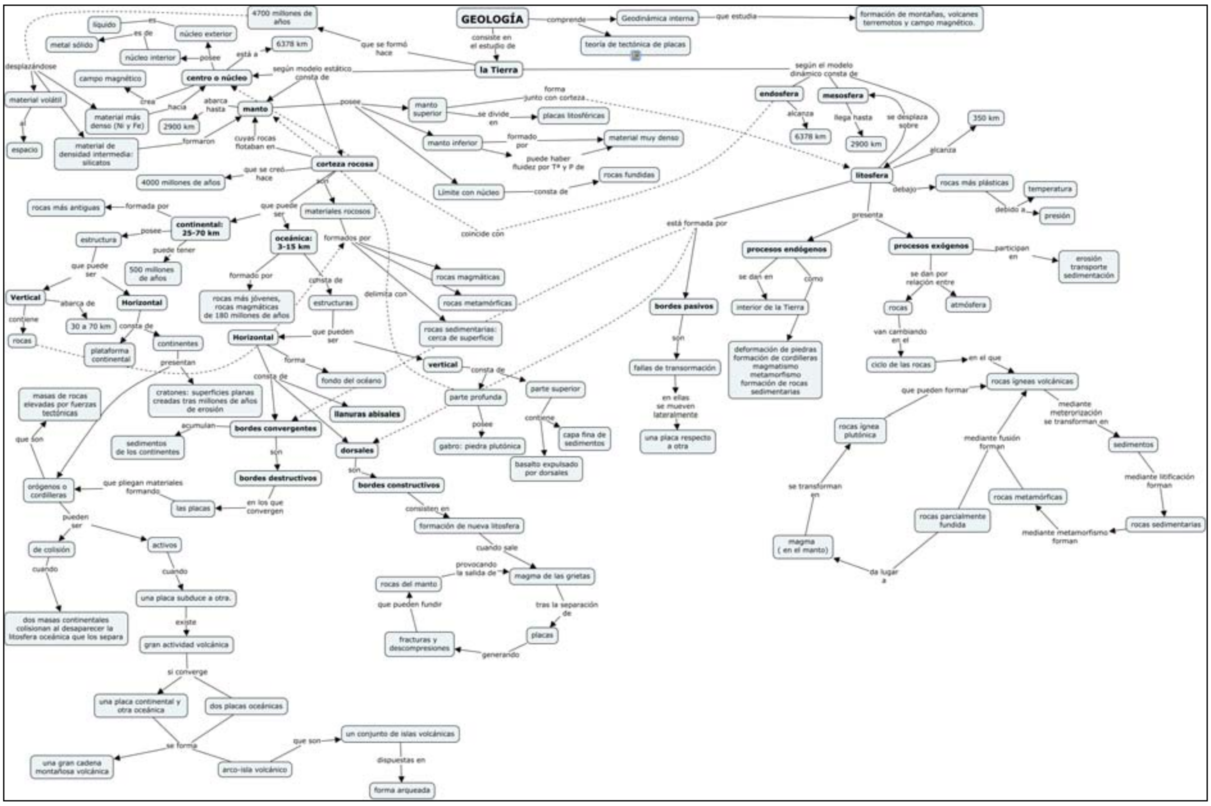

Figure 10. CM explaining the contents of the topic "Geology" in order to refresh students' previous ideas.

TNS subject is raised to refresh and evolve didactically (didactic transposition) previous knowledge of 5 blocks of contents included in the curriculum of Primary Education in Navarra (see BON), which are:

- Introduction to scientific activity
- The human body and health
- Living beings
- Matter and Energy
- Technology, objects and machines

Students work in small groups and select the most attractive block for them as a group. This is a strategy to encourage motivation. Then, they evolve the selected block, contextualized in a particular grade of Primary Education (6 to 12-year-old students), in the last practical work, which is the creation of the Instructional Module (IM), using CmapTools. The IM must include a Knowledge Model (KM) and for its creation and development, students need to have some basic scientific knowledge provided by the CCMM we designed for them and which are showed in this sequence (Figures 7, 8, 9 and 10): Biology (Living beings and human body); Physical contents (The nature of light); Chemical contents (Matter and energy) and Geological Contents (the structure of the Earth and technology). By developing the instructional module, we ensure that students work independently and acquire the skills for designing their own teaching materials in the future.

Below, we show the typical root map of an IM (Figure 11), containing the theoretical framework of the TNS subject, the KM of the selected block and the Instructional Design which includes the principles of programming, implementation and assessment which are represented by the following concepts: contextualization, organization or programming in a timetable, objectives, contents, methodologies, activities (initial, processing and summarizing), assessment, glossary and references.

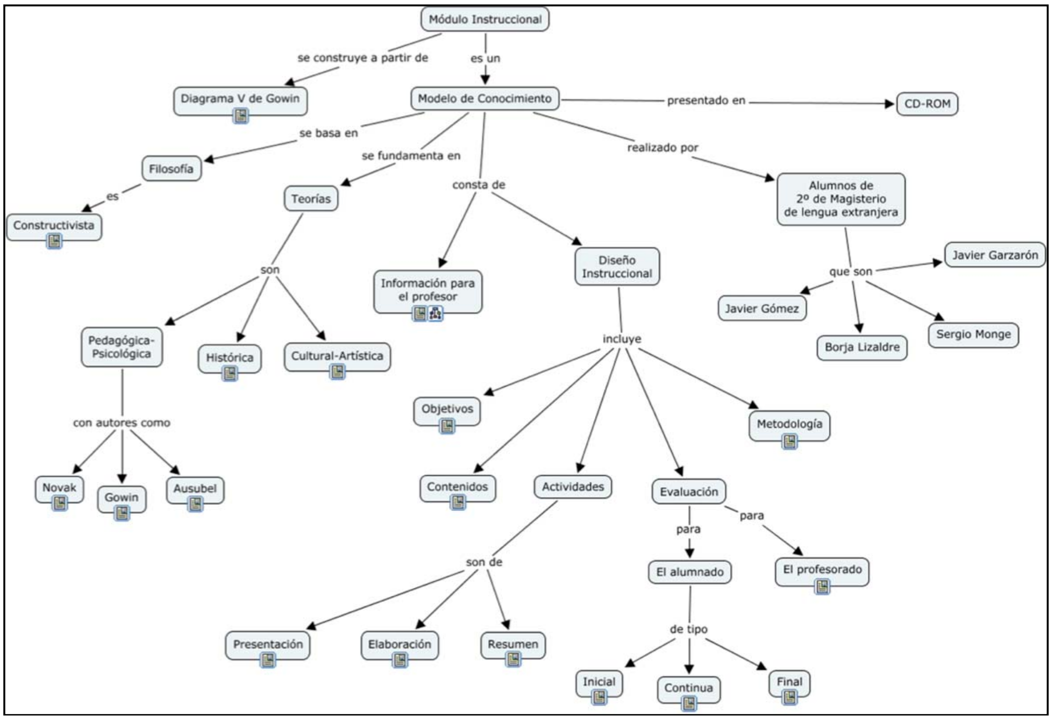

Figure 11. Example of an IM developed by a group of TNS students.

3.2 Inquiry results

A survey was done to students in order to check if they felt happy with the structure of the subject and with the theoretical and practical contents or if they had any suggestions for its improvement. The poll was filled by students who attended class in a particular day (30 students). It posed with 6 closed questions and 1 open question. Among the 6 closed questions, 22 students (73,4%) considered the presentation of the TNS course through CmapTools was practical; 21 students (70%) considered this format allowed them understand and study the contents of the three blocks of the course, better, comparing to the more conventional teaching style; 27 students (90%), confirmed there was consistency in teaching the subject in the same format that it was intended they learnt, for its application in their future as teachers of Primary Education; only 2 people (6,7%) wanted to study the theoretical contents in a more traditional teaching style; 25 students (83,3%) confirmed that they would use what they learned in the course to make their teaching materials in the future; and 22 students (73,3%), considered the teaching of the subject as a KM, enabled them to achieve the necessary skills for becoming Science Teachers in Primary Education.

The open question, was related to the quality of the teaching, being the question, “What do you suggest in order to improve the teaching of the TNS subject?”. In this case, 6 students (20%) did not answer, whereas 24 students (80%) did it. Overall they alluded to aspects related to the theoretical content of the course, to the practice, to the necessary time, the dynamism and to instructional tools. With regard to the theoretical content, 8 students (26,7%) considered important to clarify the specific contents to study for the exam or written test; 3 students (9%) wanted to explain more deeply some scientific concepts and 8 students (2,7%) suggested less theoretical content; in the case of the practice, 5 students (16,5%) wanted more practical sessions, with emphasis on the design of practical experiments held in the laboratory (3 students, 10,6%) and the possibility of taking a trip to a Natural Science Museum or to a Natural Park (8 students, 2,7%); 4 students (13,3%) indicated they missed more dynamism in class; with respect to the recommended instructional tools, 2 students (6,7%) answered CmapTools should not be the axis of the subject, and preferred to make the IM, without using the software; finally and regarding the timing, 3 students (9%) agreed they needed more time for the explanations of scientific and practical contents.

4 Discussion

TNS is a compulsory subject of the educational program of the Degree of Primary Education Teacher (DPET) at the Public University of Navarra. So far, it was considered a difficult subject by students, because they assume Science and Humanities cannot get along together. Our approach as University teachers, has been to try to use the same instructional tools we teach our students, in order to build our subject, so that DPET students, see the coherence and start imitating, by creating their own teaching material, understanding better the practicality and functionality provided by the use of instructional tools. The subject is structured in 15 theoretical sessions and 15 practical ones, in order to combine what learnt with what done to teach. It becomes a teaching –learning (university)-teaching-learning (school) chain (didactic sequence) and we have to test our proposal (using instructional tools for preparing teaching material and for teaching) is useful for our students. For that, we designed an inquiry which showed in general, students were more concerned about the theoretical contents for the exam or written test than for learning or acquiring knowledge. This fact, gives as a clue for transforming the assessment and change students' perspective, so that they rather want to know and get to a domain of knowledge than to only pass an exam. Although, perhaps this is just a question of maturity.

The software applied, CmapTools, allows teachers to generate the conditions facilitating students to transform the information in useful, substantive and transparent knowledge, to be integrated in their knowledge structure and in their long-term memory. Students play an active role, not only learning about the product and selecting the information, but through the process itself (metacognition), leaving behind the previous behaviorist-positivist model which favored mechanical-rote learning and advocating a new model, cognitive-constructivist allowing a meaningful and long life learning as well as promoting critical thinking. During the teaching-learning process University teachers try to make PET students concerned of the power they will have for shaping the society of the future when educating children. The constructivist philosophy illuminates the path to follow and authors, such as Novak, Ausubel and Gowin, provide us with the tools to create knowledge, remove misconceptions and associate emotions and learning. It has been a very grateful experience to adequate the subject to what it is being taught and we will take in consideration all the suggestions made by students for improving the subject with more practical training in laboratory, maybe visiting some Natural Science Museum or the Planetarium or taking a trip to a Nature Park in the surroundings. However, results have been very positive because students consider TNS provides them with the competences for becoming Primary Education teachers, they appreciate the consistency of being taught in the way they will have to teach in the near future, they seem motivated and committed to improving the quality of education and adapting their teaching material to the time and a great percentage of students confirm they will apply KM in their future teaching activities.

Alluding to the Ecology of Practices (Bronfrenbrenner, 1979; Kemmis & Mutton, 2009; Pérez de Villarreal, 2016), we consider TNS subject is a dynamic living being who needs to be fed and to continue raising and interacting, and any changes made, are always for the evolution of the creature and its adaptation to the environment.

References

Anta De, G. (2001). Esquemas y Mapas Conceptuales en el Aula de Ciencias. Alambique. Didáctica de las Ciencias Experimentales, vol. 15, n.3, 22-30.

Albisu S., San Martín, I., & González, F. (2006). Aplicación de los Mapas Conceptuales y de la V de Gowin en la Elaboración de Módulos Instruccionales en Alumnos de Magisterio. In A. J. Cañas & J. D. Novak (Eds.), *Concept Maps: Theory, Methodology, Technology.* Proc. of the Second Int. Conference on Concept Mapping (pp. 48-50). San José, Costa Rica: Universidad de Costa Rica.

Ausubel, D., Novak, J. & Hanesian, H. (1983). Psicología Educativa: un Punto de Vista Cognitivo. México: Trillas

Barriga, F. y Hernández, G. (1999). Estrategias Docentes para un Aprendizaje Significativo. Una Interpretación Constructivista. México: Mcgraw-Hill.

Belletich, O.; Pérez de Villarreal, O. (2015). El Imaginario Colectivo de la Educación en la Formación Inicial de Maestros, pp.95-106. In: Sánchez Sáinz-Trápaga, C., Construyendo la Nueva Enseñanza Superior, V.2. Madrid: McGraw Hill.

Belletich, O.; Pérez de Villarreal, M.; Zufiaurre, B. (2013). How to Read Assessment Criteria when dealing with Culturally Diverse Pupils? An Analysis Based on a Spanish Context. Universitas Tarraconensis. Revista de Ciencies de l'Educacio / 1135-1438. XXXVIII, December.

BON: Boletín Oficial de Navarra. Currículo de las Enseñanzas de Educación Primaria en la Comunidad Foral de Navarra. number 174, 5 de September 2014.

Bronfenbrenner, U. (1979). Ecology of Human development: Experiments by Nature and Design. Cambridge: Harvard Press.

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

Gardner, H. (1983). Frames of Mind: The Theory of Multiple Intelligences. New York: Basic Books.

Gardner, H. (2003). La Inteligencia Reformulada. Las Inteligencias Múltiples en el Siglo XXI. Barcelona: Paidós Ibérica.

Godino, J. D., C. Batanero, C., Contreras, A., Estepa, A., Lacasta, E., & Wilhelmi, M.R. (2013). Didactic Engineering as Design-based Research in Mathematics Education. Proceedings of the CERME, 8.

Goleman, D. (1996). Inteligencia Emocional. Barcelona: Editorial Kairós, S.A.

Goleman, D. (2009). Inteligencia Ecológica. Barcelona: Editorial Kairós, S.A.

González, D., and García, M (2008). Enfermedades raras en pediatría. An. Sist. Sanit. Navar 31 (Supl 2): 21-29.

González, F. (2008). El Mapa conceptual y el Diagrama UVE: Recursos para la Enseñanza Superior en el Siglo XXI. Editorial Narcea: Madrid.

González, F., Guruceaga, A., Pozueta, E., & Lara, R (2009). Making Visible Good Teaching Practices of a University Lecturer by using Concept Mapping. International Association for the Development of Advances in Technology IADAT. 5th IADAT International Conference on Education, Bilbao (Spain), June 24-26.

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

González, F., & Zuasti, J. (2008). The Running of the Bulls. A Practical Use of Concept Mapping to Capture Expert Knowledge. In A. J. Cañas, P. Reiska, M. Åhlberg & J. D. Novak (Eds.), *Concept Maps: Connecting Educators*. Proc. of the Third Int. Conference on Concept Mapping. (pp. 242-245). Tallinn, Estonia: Tallinn University.

Gowin, D. B. (1981). Educating. Ithaca, Nueva York: Cornell University Press. Trad. cast., 1985. Hacia una Teoría de la Educación. Argentina: Ediciones Aragón.

Guardian, B. & Ballester A. (2011). "UVE de Gowin Instrumento Meta-cognitivo para un Aprendizaje Significativo basado en Competencias". Revista Electrónica d'Investigació i Innovación Educativa i Socioeducativa vol. 3, n. 1. 51-62.

Herrera, E. & Sánchez, I. (2012). La UVE de Gowin como Instrumento de Aprendizaje y Evaluación de Habilidades de Indagación en la Unidad de Fuerza y Movimiento. Paradigma 33 (2), pp. 101-125.

Kemmis, S., Mutton R. (2009). Education for Sustainability (EfS): Practice and Practice architectures. Charles Sturt University. Unpublished paper. Wagga Wagga. Australia.

Meichenbaum, D., & Biemiller, A. (1998). Nurturing Independent Learners. Helping Students take Charge of their Learning. Cambridge, Massachusetts. Brookline Books.

Moreira, M. (2010). ¿Por qué Conceptos? ¿Por qué aprendizaje significativo? ¿Por qué actividades Colaborativas? y ¿Por qué Mapas Conceptuales? Qurriculum, vol. 23. 9-23, Tenerife: Universidad de La Laguna. Servicio de Publicaciones

Moreira, M. (2005), Aprendizaje Significativo Crítico, Instituto de Física Universidad Federal de Porto Alegre, Brasil: Editora da UFRGS.

Moreira, M. (2006). A Teoria da Aprendizagem Significativa e sua Implementação em sala de Aula. Brasília: Editora da UnB.

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

Novak, J. D. & Gowin D. (2005). Aprendizaje Significativo: Técnicas y Aplicaciones, Ediciones Pedagógicas. USA: Cincel.

Novak, J. D. & Gowin, D. (1988). Aprendiendo a Aprender.117-10 Barcelona, España: Ediciones Martínez Roca, S.A.

Novak, J. D. & Cañas, A. J. (2006): The Theory Underlying Concept Maps and How to Construct Them (Technical Report IHMC CmapTools 2006-11). Florida Institute for Human and Machine Cognition.

Novak, J. D. (1998). The pursuit of a Dream: Education Cam Be Improved. In J. Mintzes, Wandersee J. and Novak, J. Teaching Science for Understanding. A Human Constructivist View. San Diego: Academic Press, pp. 3-28.

Novak, J. D. (1998). Learning, Creating, and Using Knowledge: Concept Maps as Facilitative Tools in Schools and Corporations. Mahweh, NJ: Lawrence Erlbaum Associates.

Novak, J. D., & Gowin, D. B. (1984). Learning How to Learn. New York: Cambridge University Press.

Ontoria, A. (C) (2001). Mapas Conceptuales. Una Técnica para Aprender. Madrid: Narcea.

Pérez de Villarreal, M. (2016). Teaching Sciences Positively (pp. 133-155). In: Zufiaurre, B. and Pérez de Villarreal, M. Positive Psychology for Positive Pedagogical Actions. New York: Nova Publishers.

Posner, G., Strike, K., Hewson, P., & Gertzog, W. (1982). Accommodation of a Scientific Conception: toward a Theory of Conceptual Change. Science Education, 62 (2), pp. 211-227.

Rodríguez, M., Caballero, C. & Moreira, M. (2010). La Teoría del Aprendizaje Significativo: un Referente aún actual para la Formación del Profesorado. Actas del I Congreso Internacional Reinventar la Formación Docente. Universidad de Málaga; 589-603.

Sánchez, I. (1999): El Mandala y la Uve de Gowin en la Enseñanza de la Física. Paideia, vol. 27, 47-60.

Villar, L., & Alegre, O. (2004). Manual para la Excelencia en la Enseñanza Superior. Madrid: Mc Graw Hill.

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Learning: Alternative Conceptions. In D. L. Gabel (Ed.), Handbook on Research in Science Teaching (pp. 177-210). New York: Macmillan.

Zufiaurre, B.; Belletich, O. (2014). Neoliberal Imaginarium for Conservative Educational Practices. Knowledge Cultures, 2(4), pp. 45–63.