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Using Didactic Transposition Theory and the Concept Maps Tool to Build a Theory of Scientific Knowledge

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Abstract: We will present here the Scientific Knowledge Theory (SKT) along with one of its possible research methodologies, that is, together with concept mapping as an algorithmic language (CMA). That is, at the moment that a given author produces a given text or hypertext, to be this an educational text, a report, an article or scientific text it "materializes" as a set of ideas, hypotheses, explanatory models, theory and/or experimental facts in a written form, implied in its most general form. In this moment we have the occurrence of an "educational fact." It is proposed here that a theory of Scientific Knowledge Transposition or Didactic Transposition, provided with a research methodology and based on pedagogical facts constitutes a branch of the social sciences. That this new theory, the "Theory of Scientific Knowledge", can be easily generalized to other forms of knowledge. Its basis will be formulated on the sciences of physics and mathematics. As an application we will study the structure of knowledge of Max Planck's theory of Blackbody Radiation and how it is transposed to the various educational levels.

Keywords: Theory of Knowledge, Teacher Training, Didactic Transposition, Concept Mapping, Scientific Methodology

1. Introduction

I will restrict the field of study of this article to the scientific knowledge structure and its transposition or translation into accessible language, more specifically to Physics and Mathematics. Although all knowledge comes from observing and interacting with Nature and is recorded and divulgated verbally or orally and is therefore subject to study by the laws of semiotics and anthropology, we are obligated here for the sake of clarity and the construction of a theory to restrict us to scientific or systematized knowledge according to certain pre-established academic rules. Until now it is very difficult, if impossible, to concisely define what scientific knowledge would be. Even if possible, this definition would not be useful to us for didactic purposes, for artificial intelligence science or for the informational system. Let us begin with the most current definition of major natural science would be.

i. Physics is the science that studies matter, the various forms of energy and their interactions.
ii. Chemistry is the science that studies the structure of substances, the composition and properties of different materials, their transformations and the energy involved in these processes.
iii. Biology is the science that studies life and living organisms. Biology is divided into several specialized fields covering the morphology, physiology, anatomy, behavior, origin, evolution and distribution of living matter, as well as vital processes and relationships between living beings.

These definitions are not useful even for curricular analysis purposes, much less for creating an algorithm that simulates scientific thinking. These do not allow us to differentiate between nuclear and solid state physics. But these definitions inform that these subjects have to be study separately. What about Mathematic? According to Galileo Galilei (Dialogues between two sciences) the universe was written using the alphabet of mathematics. But the word mathematics does not appear in any of the above definitions. Let's look at one of the definitions of mathematics? In his exceptional introductory treatise, "What is mathematics?" Courant and Robbins wrote:

i. Mathematics as an expression of the human mind reflects active will, contemplative reason, and the desire for aesthetic perfection. Its basic elements are logic and intuition, analysis and construction, generalization and individualization. While different traditions may emphasize different aspects, it is only the interplay of these antithetical forces and the struggle for their synthesis that constitute the life, utility, and ultimate value of mathematical science [13].

Where would the description of geometry and algebra be? Thus this article will be restricted to the definitions of science provided by the didactics, epistemology and neuropsychology sciences. P. Ernest states [17]:

Essentially, mathematics should be considered from two points of view: (a) mathematics as a formal and deductive body of knowledge, as set forth in high-level treatises and books; (b) mathematics as a human activity.

Thus mathematics is a scientific knowledge as defined by Chevallard [9]. That is, a set of knowledge defined in each age that must be appropriated by human beings. Thus we will generalize this idea to all sciences and say in general that science is a scientific knowledge, that is, a body of knowledge plus the human skills developed due to (from) its practice or training. In this way mathematics will be analyzed as a separate case. We will put it aside the others sciences.

So, scientific knowledge will be analyzed as it appears in textbooks. The multiplication and universalization of university careers led to the explosion of the Editorial Market, both in the bachelor degree as in the secondary school. The combination of engineering with the agricultural, environmental, foods and other sciences created the necessity to produce a wide variety of specialized textbooks. This created opportunity to the emergence of several educational proposals for science teaching. In particular there are Physics books with the purpose of training scientists, engineers and biological sciences. There are calculus books for engineers and for mathematicians.

These books and e-books are composed of texts produced according to a teaching methodology with very specific purposes and in accordance with the prior mathematical knowledge of each student. Thus, they are the materialization of a didactic transposition [9, 27] of scientific knowledge and called hereafter the "Pedagogical Fact" (a material object). We will use the term pedagogical fact even if the knowledge is produced in the form of a hypertext or as a figure, graph, table, or website[1].

The theory that studies how this pedagogical fact occurs is called the Didactic Transposition (DT) [9]. That is, DT is the theory that studies how the knowledge produced in research spheres are transformed and consolidated in knowledge to be taught both in higher education as in the educational basic cycle. That is, we will use as theoretical framework the generalized theory of DT of Chevallard, Izquierdo and De Mello called DT-CHIM [28].

It can be shown that Concept Maps used as this was an algorithmic language (CMA) is the best and most efficient way to make the analysis of how scientific knowledge produced in research spheres is transposed to textbooks, consolidating as a pedagogical fact. Using this study tool (CMA) was possible created a research methodology for the DT [30, 31].

The main objective of this article is to demonstrate that the theory of DT-CHIM together with their pedagogical facts and equipped with the research methodology based in CMA is a social science. We will use as an applying example the quantization theory of Max Planck.

2. Pedagogical Facts and Its Research Methodologies

With the emergence of the World Wide Web, with the democratization and universalization of education and information the knowledge has become an integral and fundamental part of current society - the information society [6, 26]. Knowledge is no longer an accessory of production and marketing process and has to be considered a central and decisive part of the structures and rules governing these [17, 18]. Similarly, various theories and methodologies have been created, developed and adapted to meet the needs and the development of the media and cybernetics.

Within this methodology, called data mining, we have several software or applications developed with the purpose to obtain information and manage the market. Among these we have the Oracle software, SAP and others [8]. Basically these use resources of statistics along with the operational research theory (a methodology of research) to perform data processing.

From these researches are developed marketing strategies, advertising campaigns, product portfolio, products alteration, etc. Despite the motivation behind this research, according to Adam Smith [39], is the greed of the entrepreneur, the knowledge generated by this research (scientific methodology) is prepared in an intelligible form and scientifically. So we can call it a pedagogical fact. Even the design of a home page is made according to certain logical rules based on scientific knowledge coming from psychology and statistics and can be call a pedagogical fact.

Due to the impact of the multimedia, especially by the visual presentation, it caused the publishing companies to invest in the research of the impact of graphic arts over reading and text comprehension [7, 34]. It has been shown that fully integrated figures into text contribute significantly in the reading and understanding of scientific texts and text in general [11]. As this knowledge results in the production of certain kinds of books we may call it pedagogical fact.

In sequence we restrict ourselves to the study of how scientific knowledge is transposed to textbooks and how this becomes a pedagogical fact, that is a textbook (a material object), using concept mapping as a research methodology.

1 Henceforth any materialization of knowledge will be called event or educational fact.

3. The Chevallard, Izquierdo and de Mello Theory of Didactic Transposition (DT-CHIM)

Briefly the Didactic Transposition Theory is a theory that involves the epistemology of science, cognitive theory of science, didactic teaching and social theories to understand, create rules and study the mechanisms governing the knowledge transformation produced in research environments to suit academic teaching, from this to the textbook and from this to the classroom of basic university course and for school basic cycle. In other words, this theory aims to understand how scientific knowledge is transformed in its multiple forms of presentation. That is, as this is rewritten according to certain teaching methods and educational purposes.

The theory of DT studies how the knowledge produced in research spheres, called scholarly knowledge [10], is transformed, adapted and rewritten in the form of school scientific knowledge, called Knowledge Taught. As Halté points out [1998] Chevallard elaborated his "theory" in journalistic form. That is, in the form of the description of the social factors of how the scientific community and educators transform academic knowledge into school knowledge. But we will study here the epistemological reasons that govern this translation. Note that Chevallard [9] and others address various epistemological problems in mathematics teaching or its DT, but as examples of didactic system intervention and not as general rules of how DT should occur.

In the general theory DT-CHIM [27, 30] the DT theory should consider that the knowledge produced in research spheres goes through three steps to get to the basic education classroom. That is, the Scholar Knowledge is consolidated and/or regulated in the post-graduate programs, then transposed to the Bachelor level and is finally transcribed or adapted to the level of the textbooks produced for the basic cycle of school[2] (Knowledge to be Taught). This is necessary because currently we have textbooks designed for post-graduate courses and graduation. Strictly speaking we would have to subdivide the bachelor in academic and basic graduation. So we have to divide the Scholar Knowledge into three parts. Scholar Knowledge (Research Level), the Academic Knowledge (Level Postgraduate) and the University Knowledge (graduate degree).

Scholar Knowledge → Academic Knowledge → University Knowledge → Knowledge to be Taught → Knowledge Taught.

It is within this context that the DT theory deals with the problem to understand, classify and study how the knowledge produced in the academic spheres will be adjusting, adapting and transforming into scientific knowledge taught in the classroom[3]. That is, what school science and the science of scientists have in common is that their theoretical ideas, their concepts, once consolidated, are transcribed and recorded (sealed) within textbook theories (black boxes) - Latour Thesis [25]. That such a packaging process leaves out the details, explanations, and reasons that were previously necessary to convince others of their "original power of explanation" – as much scientific as well as didactic level [21]. In this way the scientific knowledge is reworked and restructured in order to be transmitted, that is, divulged.

Chevallard [10] divides the DT into external DT or Lato Sensu and internal DT or Stricto Sensu. Chevallard focuses his studies on describing external transposition. That is, which mechanisms and actors participate in the process of transforming academic knowledge to the book or didactic guidelines. See figure 1. Chevallard[4] [9] were not concerned with how this knowledge (the knowledge to be taught) turned into the "taught knowledge" in the classroom.

We divide the theory of DT in two parts [27]. One part of the theory deals with the socio-cultural influences on didactic teaching [10, 3]. The other is concerned with the epistemological and semantic aspects of the theories and how these are translated to textbooks. See figure 2.

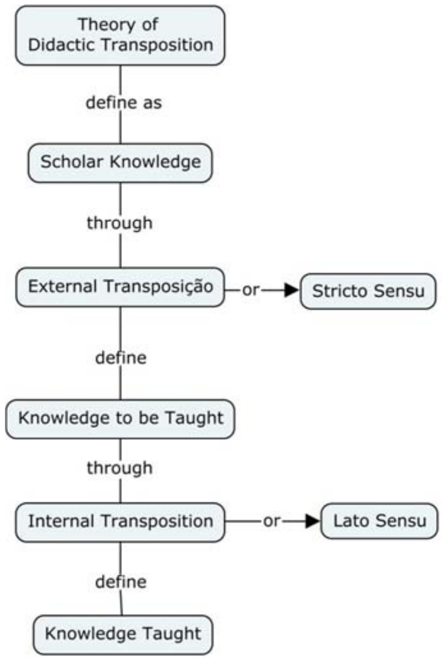

Figure 1. *Theory of Didactic Transposition after Brousseau.*

Although apparently seem that these two aspects of DT not influence each other, they coexist and work together. So, one has to include in their analysis the external environment in which it occurs. That is, one has to take into consideration that the school system is part of a larger system - the education system [3]. Chevallard [10] uses the noosphere word to describe and encompass the elements involved and regulating the selection and determination of the changes that scientific knowledge will suffer to become school knowledge. More details see Brockington [3] and De Mello [30].

2 Elementary and secundary.

3 Here is meant classroom the class in the basic cycle.

4 And I in previous work.

Due to the diversity and richness of existing factors in the academic sphere governing the selection and standardization of scientific knowledge we called this environment as epistemosphere. Within this epistemosphere we have, in the case of exact courses, Physics books written for courses based on calculus and others based on algebra. We have Physics books called Conceptual Physics, Physics for Engineers and traditional. We have calculus books for engineering and others for mathematicians. It can be shown that [27 and 30] the DT for the basic cycle occurs from these texts and not from the original articles. Thus a theory of DT must study and show how knowledge or Scholar Knowledge is transformed into the epistemosphere to transform into Knowledge Taught.

After this phase, knowledge is transformed within the context of editorial policies, national programs of textbooks production and formulation of public policies to achieve the textbooks and be effectively taught in the classroom. Is in this moment that the teaching methodologies and pedagogical proposals come into play. That is, when studying or analyzing the transformations that knowledge suffers to reach the school environment we should consider both the epistemological aspects of science as their pedagogical and methodological aspects of teaching.

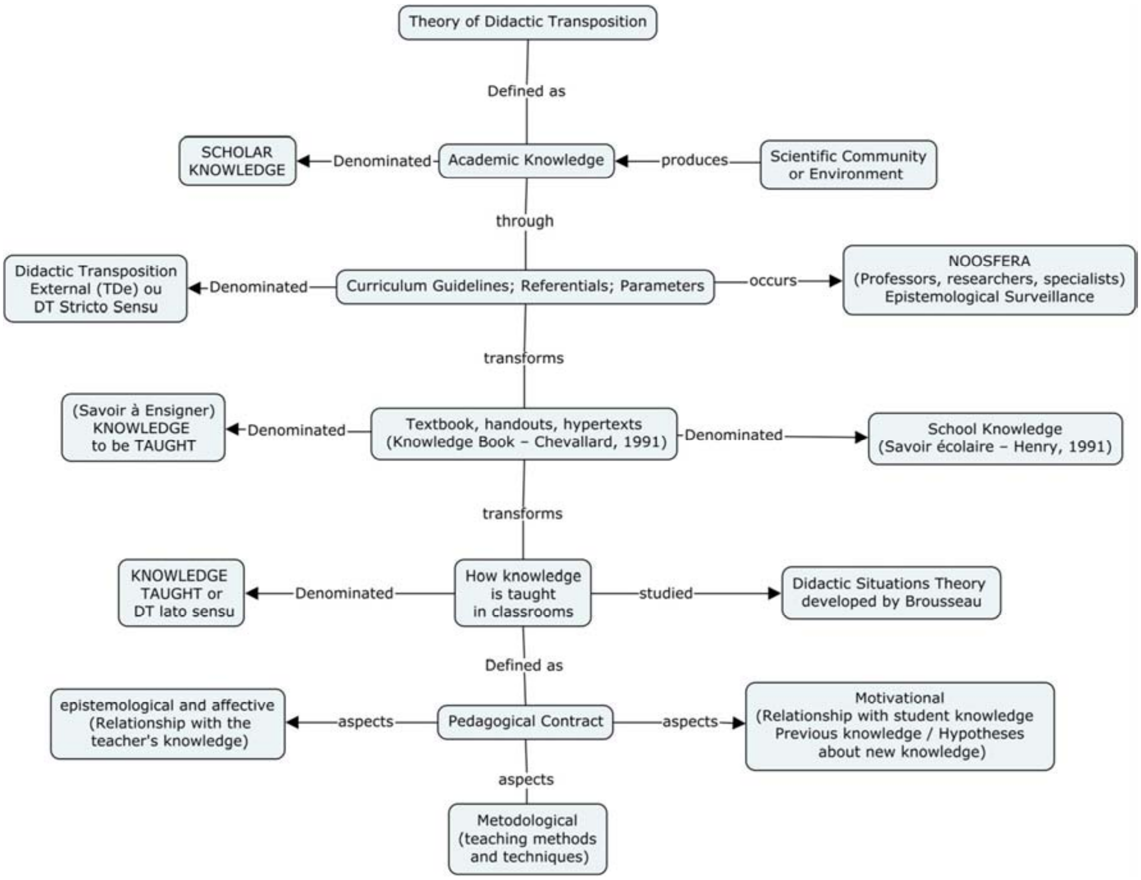

Figure 2. *The Theory of Didactic Transposition plus the Didactic Contract.*

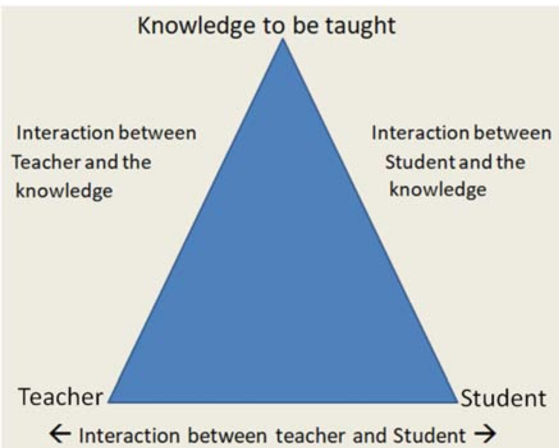

Figure 3. *Pedagogical Triangle [1].*

For the sake of completeness I must report that the theory that studies how knowledge is worked in the classroom is called Brousseau's Theory of Didactic Situations [4]. In mathematics didactics this fact is described by Brousseau as a didactic contract and pedagogical situation. That is, the teacher must create a special learning environment, called the milieu, where students feel motivated to learn math and its ways of thinking. Thus, for each teaching methodology the teacher must prepare the most appropriate milieu for this. For example: computer room, lab room, play room, etc. [1, 5]

4. Didactic Transposition and the Cognitive Model of Science

Recent contributions from epistemology of science for science teaching led to a new approach (theory) of the latter called "cognitive model of science" (CTS) that originates from Kuhn's philosophy of science [21]. Along with the theory of "didactic transposition" suggest the possibility to analyze with more depth as knowledge produced in scientific spheres are translated to the school sphere. To understand how the knowledge produced in research spheres (scholar knowledge) is transposed to the university and school spheres we should take into account what is actually meant by scientific knowledge and to do science in school level.

To teach science we have to teach systems or methods of acquiring knowledge and at the same time, teach how to arrive to this organized body of knowledge from them. But in general it is impossible to reproduce in the classroom [22]. Thus, the question arises: What is to teach science in high school classroom as in the university?

Scientific theories are presented in textbooks as a set of models related to some facts and some identifiable instruments that give meaning to the theory. Relations between the models and the facts are developed through postulates and theoretical hypotheses supported by experimental facts. Therefore, a scientific theory is a family of models and assumptions together with or postulates establish the similarity of these models with experimental facts.

These explanations, that is, theoretical ideas about the world created to understand it, are structured around concepts. For Latour [25], these concepts, or what he calls knots or links, are those things that allow us to understand the scientific activity [21]. Thus, it is argued here that concept mapping is the ideal tool to do this study. Mainly, how these concepts or nodes or links are inserted, deleted, summarized and twisted to make each text a coherent whole.

What would be the equivalent of Brousseau's milieu for physics and chemistry? According to Izquierdo-Aymerich [21][5] for didactic reasons teachers simplify and define what is or do science (DT) describing it as a way of thinking and acting in order to interpret certain phenomena and to intervene through a series of structured theoretical and practical knowledge. The goal of science education is make students to understand that the natural world has certain characteristics that can be theoretically modeled. Because of this we present to them, making a DT, some reconstructed facts, theoretical models, arguments and propositions that were previously selected.

In addition, if the teaching of sciences is done in accordance with the principles of meaningful learning [2], that is, a well executed didactic transposition [10], the teachers will be involved in the task of connect scientific models to used by pupils themselves, using analogies and metaphors that may help them to move from the last for the first [12, 14, 15].

If we analyze the Physics textbooks written for high school, from the point of view of knowledge and its method of obtaining, we see that these are classified into two types: a) those who start exposing the theory and then presenting the experimental facts that leads to its formulation or discovery as a mere confirmation of its validity or importance. b) and those that begin exposing the experimental facts that resulted in its formulation and putting the theory as a direct consequence of these facts.

On the other hand, mathematical theories do not become obsolete and mathematics need not be confronted with experimental facts. Thus mathematical theories need not be grounded in experimental facts. But, on the other hand, as discussed in de Mello [30] mathematics is both knowledge and a form of reasoning. How can we read in Ponte [37]: mathematics can be viewed as a body of knowledge, consisting of a set of well-defined theories (perspective of mathematics as a "product") or as an activity (consisting of a set of characteristic processes). It can be argued that both product and process are equally important, and only make sense if equated together. It will be impossible in this case to explain to someone what mathematics is without presenting an example in which their own processes are simultaneously used and illustrated with concepts from one of their theories.

Thus textbooks seek to impart knowledge as well as develop mathematical reasoning in their students. Thus mathematics is a scientific knowledge as defined by Chevallard [9]. That is, a set of knowledge defined in each age that must be appropriated by human beings.

Thus, when analyzing mathematical knowledge we must take into consideration the works of Jean Piaget [35] on the stages of development of intelligence or cognitive abilities, as well as of others Authors [16, 20, 37, 40] on the role of problem solving in understanding and articulating mathematical knowledge in the handling and understanding of mathematical concepts. We can read in NCTM:

Understanding concepts is not limited to knowing their definition - it also requires understanding how these concepts relate to each other and how they can be used in problem solving. In addition, understanding procedures is not only about their application, but also about understanding why they work how they can be used and how their results can be interpreted (NCTM, 2009).

5. Concept Maps and Concept Mapping

Concept Maps is a concise way of presenting and connect concepts [33, 32]. As this is a form of mapping it uses linking words to connect ideas or concepts. Due to the variety and freedom to graphically present the concepts we have that MC is the ideal tool to evaluate, present, synthesize and summarize the knowledge [34]. Novak [34] defines an in broad manner what are conceptual maps (CM):

*"*Concept maps are graphical tools for organizing and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two

5 The following two paragraphs are a collection of statements that together form the definition of that is the DT from the CTS point of view.

concepts."

When the CM is well constructed allows the visualization and perception of how the keys concepts from a particular topic or field of knowledge follow one another, intertwines and organizes themselves in the structuring of this knowledge. Thus, it is desirable to create some ground rules for the construction and standardization of CM, that can be seen in many articles [31, 32, 34]. Contrary to one of the basic principles of MC construction, one has that in the case of a systematic study one must create some very specific rules for the construction of CM, so that they become a kind of algorithmic language.

Due to its concise, hierarchical and graphical way to present the key concepts to be taught we have that CM are a powerful tool to perform the analysis of the conceptual framework that textbooks are written. The construction of a CM to a topic or the whole book, allows you to see promptly and succinctly the conceptual framework that a particular Author used to concatenate and organize the key concepts that go into the preparation of your textbook. Thus, it is necessary to build a CM wich show us the interconnection between the concepts inserted and used, and enables to quickly view the underlying structure used to the construction of a conceptual body of knowledge. More details about MC see Novak [33] and Moreira [32].

5.1. Conceptual Maps, Didactic Transposition and Cognitive Models of Science

As stated above, scientific theories are constructed from scientific models, assumptions and theorems that are propose to explain a certain set of events. These explanations are structured around concepts, nodes or links [25], which allow us to understand the scientific activity [21].

Thus, being CM diagrams of meanings, indicating hierarchical relationships between concepts or between words to represent concepts, these are the ideal tool to map as these nodes or links are prepared and organized so as to create a coherent whole and that make sense to a certain level of schooling. That is, to study how the knowledge produced to a level of schooling is transcribed to another.

As demonstrated in the literature [29] for the case of the subject of physics called photoelectric effect, that in general the scientific knowledge when transcribed to the textbooks is structured in a didactic way in: a) models; b) the core of the theory; c) experimental facts; d) the key concepts; e) the methodology and f) the application of the theory. Thus, it is necessary to understand how these "pieces of knowledge" are inserted, deleted, and summarized to make each text a coherent whole.

It can be show that when the original theory was built in a period of paradigm revolution [24] the theory need firstly be consolidated in the new paradigm before suffer a DT to the high school level. That its originals explicative's models must be adapt or rewritten in this new paradigm [29].

So, the CM built to analyze how the knowledge suffer a DT must be constructed under some rules. In this the conceptual structure described above should be very clear. Like an algorithm it must be created with the finality of describe the knowledge structure. Thus, the CM builder must be trained in dissect the knowledge in its fundamental parts.

5.2. Concept Maps as Algorithm to Analyze the Knowledge

The main objective of this article is to demonstrate that the use of CM was as an algorithmic language to conduct the study of DT or the Theory of Knowledge (TC) is a scientific methodology. That this methodology, together with the theory of DT-CHIM, constitutes a theory of school science knowledge. As an example of application of the theory of knowledge and its methodology we will present a summary of the study of the didactic transposition of the Max Planck article to textbooks. That is, as through this DT the theory of blackbody radiation (RCN) and the theory of quantization become an educational fact. More details see De Mello [29].

The methodology used here will divide the knowledge into its constituent parts and analyze using MC how these parts are arranged didactically to become a coherent whole and that makes sense to a certain group of people (students). To facilitate this task we will use certain rules to perform this mapping. Just as in a flowchart created to describe a computational algorithm we have specific symbols that define specific operations or actions, created in order to facilitate and standardize their reading, we create specific symbols or colors for a particular concept mapping.

In the case of scientific theories, called here the "knowledge", we have that these consist of a) explanatory models; b) the core of the theory; c) the key concepts; d) methodology; e) experimental facts and d) the application of the theory. So we use green boxes to identify the models. Boxes in blue to identify empirical laws, or its conclusions, or the results. In purple we have the theory. We put in yellow boxes the experimental facts that resulted in the theory. Green bluish the title. Light blue represent all support material, such as equations, deductions, etc. Finally, we put on coral the generalizations or universalizations of the theory. In this case we have no theory applications. See Figure 4.

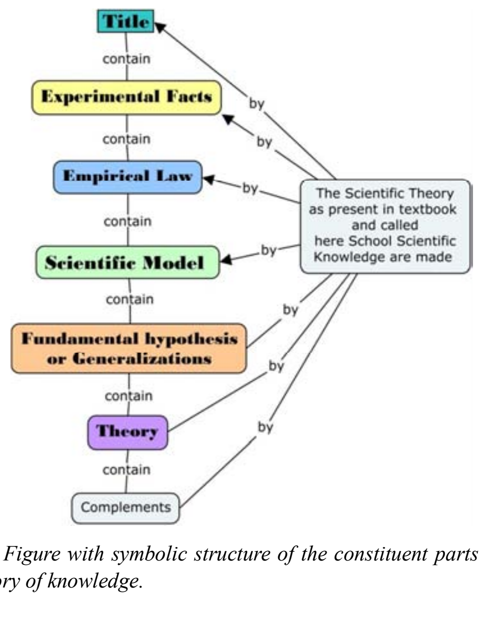

Figure 4. *Figure with symbolic structure of the constituent parts of a CMA to the theory of knowledge.*

In the case of mathematics, as we discussed earlier, this is a body of knowledge and at the same time a way of reasoning and acting. Thus mathematics is a set of knowledge defined in each age that must be appropriated by human beings. It has a body of knowledge - arithmetic, algebra, infinitesimal analysis, probability theory, set theory, topology, differential geometry, functional analysis... but it is built using the rules of logic and mathematical formalism, and it is the tool in which the formal "structure" of all other sciences is constructed. Thus mathematics is supported by the tripod: Formalization, Verification and Universalization or Generalization. See figure 5.

But there is a fundamental difference between mathematics and the other sciences. While in the other sciences, even though well-formalized, their theories may be rejected because their conclusions cannot be confronted with experience, mathematics exists on its own. That is, it only depends on the rigor of mathematical reasoning. Thus, in mathematical knowledge there is no need to highlight experimental facts.

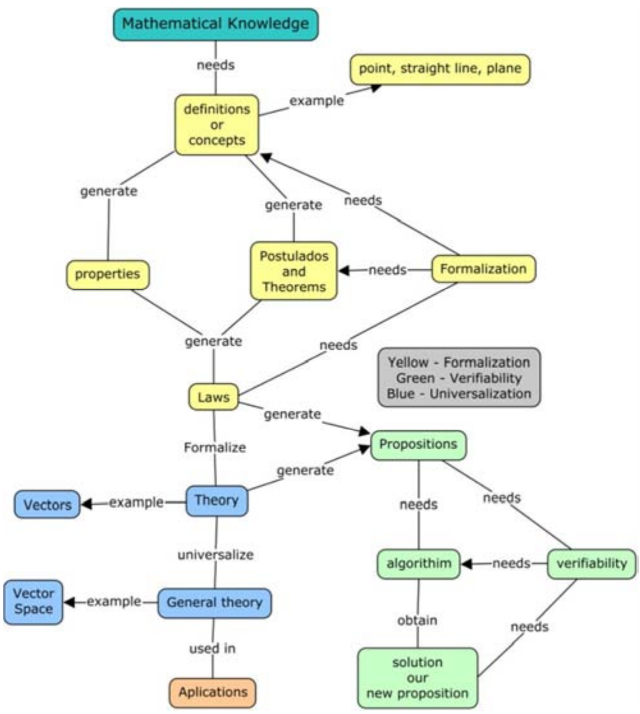

Figure 5. *Mathematical Knowledge.*

Unlike physics where it is possible to define or describe in a single way the school physical knowledge, but we do not have well defined what would be the physical reasoning, in mathematics the opposite occurs. It is not possible to define or describe in a single way the school mathematical knowledge, but we have well-defined what mathematical reasoning would be. See figure 6. For example, the structure of the calculus textbook is completely different from the structure of the linear algebra textbook.

In the case of the science of physics and chemistry, the way in which particular scientists, for example Einstein, Landau and Newton, reason in order to generalize physical and chemical theories is still undetermined. Thus we put a general idea of how scientific reasoning works and the formalization of the theories of these sciences in figure 7 (end of text).

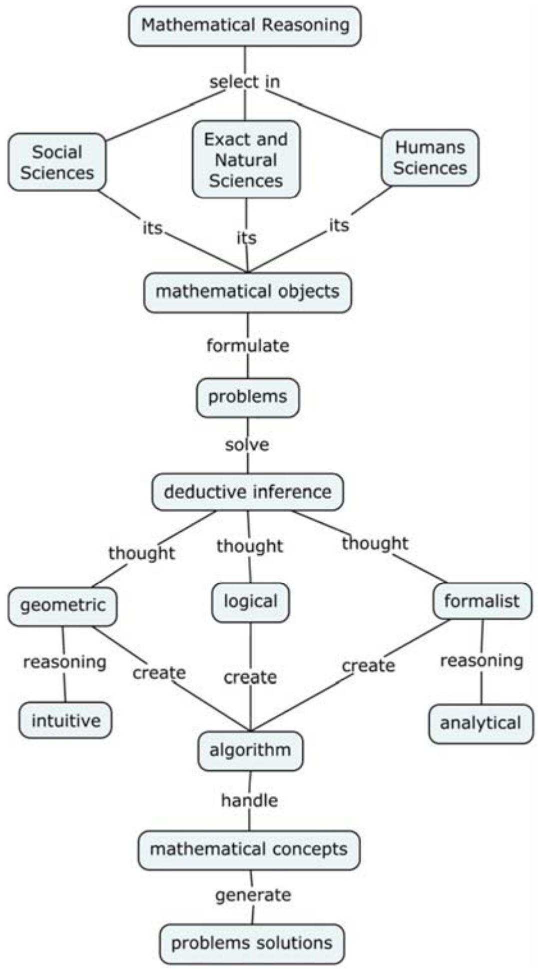

Figure 6. *Mathematical Reasoning.*

6. Results

The Quantization Theory of Max Planck (1901).

In some textbooks as well as to teach classes at the university basic cycle the theory of Max Planck's quantization is presented, suffering a DT, as merely an ad hoc hypothesis made by Max Planck [36] to explain the radiation spectrum of blackbody (BBR). There is no exposure of explanatory models or experimental facts that resulted in the theory [6] That is, they report that Planck postulated the quantization of energy through the equation

$$E = h.\nu$$

For example, the book Fundamentals of Physics [19] is a pedagogical fact (product) arising from this type of DT.

6 Because of the tradition we use the name theory for all this body of knowledge. When appropriate we will use the word knowledge as defined by de Mello (2016d).

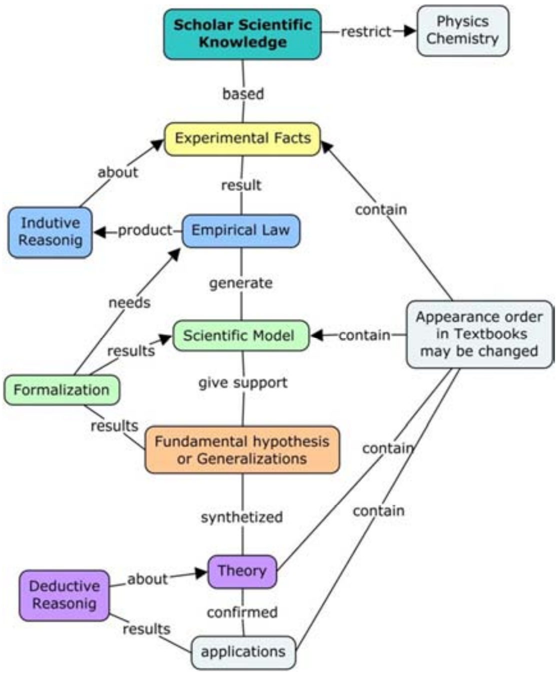

Figure 7. *Scholar Scientific Knowledge and Scientific Reasoning.*

In other texts or pedagogical fact this theory is summarized in definition of BBR, presentation of the empirical laws that preceded the Planck Law and his hypothesis. There is no elaboration of an explanatory model and there isn't a discussion of how this was developed in the old scientific paradigm. See Figure 8 (end of text). It is very common to find this form of summarized presentation of the theory of BBR in texts to form engineers in general [41][7].

We put down the CMA of the Max Planck original article [36]. Analyzing Planck's theory we clearly see the structure and the brilliance of his reasoning. That is: a) Definition of BBR and presentation of experimental facts; b) followed by an empirical law; c) attempt to write the theory from universal principles, boxes in peach color; d) model in the old paradigm, boxes in green; e) Deduction of universal law, boxes in purple.

As an example of an educational fact originated from a didactic transposition we chose the textbook Jewett [23]. Analyzing your CMA we clearly see the yellow boxes (experimental facts) scattered and concatenated with blue boxes (empirical laws), and in the last line we see as Planck's hypothesis (new paradigm) is inserted in theory. See figure 10 (end of text). Despite the greater emphasis given to the explanation of the experimental facts and to the empirical laws that resulted in the Planck Law, we can note that this text was prepared in the same structure of Planck's article, that is: Facts and experimental laws → explanatory model → theory. We see the degree of preparation of the theory presentation of BBR that this book is really designed to train scientists in general. It is easy to note that it would be much harder to do this analysis if we had a CM without the color codes (CM clean)[8].

7. Conclusions

We see above that MCA is the ideal tool to make the study of how scientific knowledge is transposed to all spheres of knowledge. This provides a very effective scientific methodology to make the study of the implementation of knowledge.

The DT-CHIM theory provides a general guidelines and rules to determine how certain scientific knowledge perpetuate and update in the school spheres. It also provides rules on how to classify the DT and how it should be done.

The CMA together with the theory of DT-CHIM is a very effective tool to classify, analyze and summarize how scientific knowledge is developed, formulated and transcribed to educational spheres. That is, to classify pedagogical facts.

With the DT-CHIM together with the scientific methodology using CMA we obtain a very effective way to make the study of how scholar knowledge is transformed in scientific environments. They become a science of scientific knowledge.

The CM prepared according to the algorithmic rules provides us a schematic, visual summary and ordered the ideals, concepts and everything that makes up an article and / or book. The colors call the reader's attention to its constituent parts, so that in a first reading in addition to an overview of the content colors of the text, it allows and calls the reader's attention to its constituent parts. That would be more difficult if we only had the CM without color code. If the reader does not know in advance that a given knowledge consists of theory, models, etc. there is a great possibility that pass unnoticed any of these items, and that the reader does not understand in depth all its contents.

The CM in the form of algorithm (CMA) will indicate which sequence the author entered, organized and concatenated the component parts of his theory (knowledge). Moreover, the analysis done for a CMA for a particular textbook allows you to view how these concepts or nodes or links are inserted, deleted, summarized and twisted to make each text a coherent whole. Used in a comparative analysis it allows you to check: a) as explanatory models are adapted, simplified and deleted; b) how the knowledge of the contents are transposed into a teaching methodology of science, suffering a didactic transposition; c) when applicable, how knowledge is implemented and consolidated in a new scientific paradigm.

Although we have not looked at any mathematical textbook, we can see in Figure 5 how the MCA structure of mathematical knowledge allows us to see how it is built in three blocks (tripod): Formalization, verification and generalization. That although the structure of mathematical knowledge is slightly and fundamentally different from that

7 More details see [26-28].

8 On de Mello [29] it can find the TD analysis for the medium level performed on the example of the Glencoe program.

of physics (chemistry), MCA is the ideal tool to do your analysis.

Like any field of scientific knowledge, especially human, this is very dynamic and challenging. So that the DT-CHIM presented above should be considered within its scientific and pedagogical actuality. They are based on years of work by researchers like Chevallard, Izquierdo, Johnson-Laird, Nerssessian Brousseau, and others.

Although we have achieved, through the analysis of textbooks using as a tool conceptual mapping prove some of the ideas proposed here, there may be needed to include, replace or reformulate some of these. It follows, therefore, that the study of pedagogical facts using the DT-CHIM together with the methodology of science CMA is a consistent theory of knowledge.

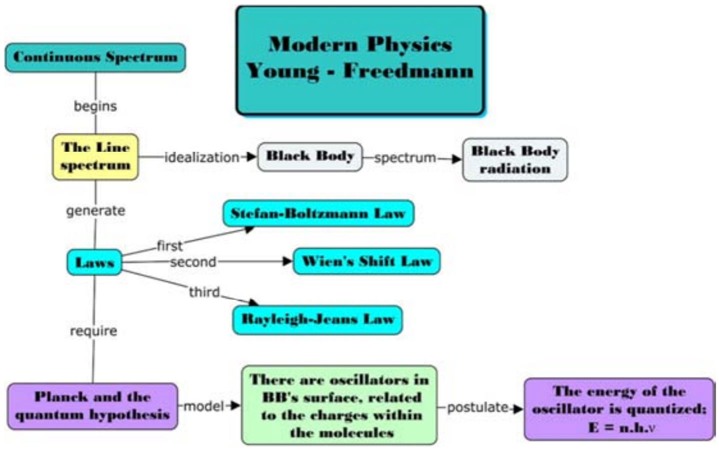

Figure 8. The CMA to the text of BBR theory of Young-Freedemann textbook [41].

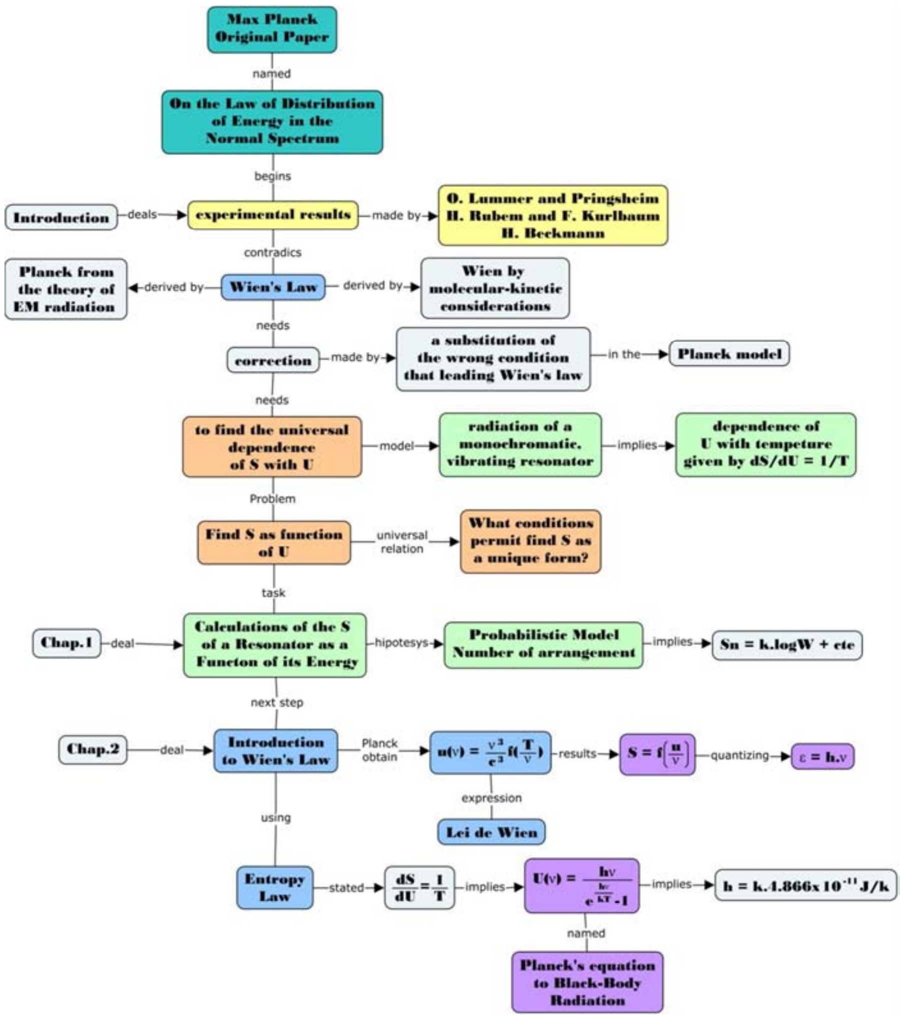

Figure 9. The CMA of Max Planck article about BBR theory.

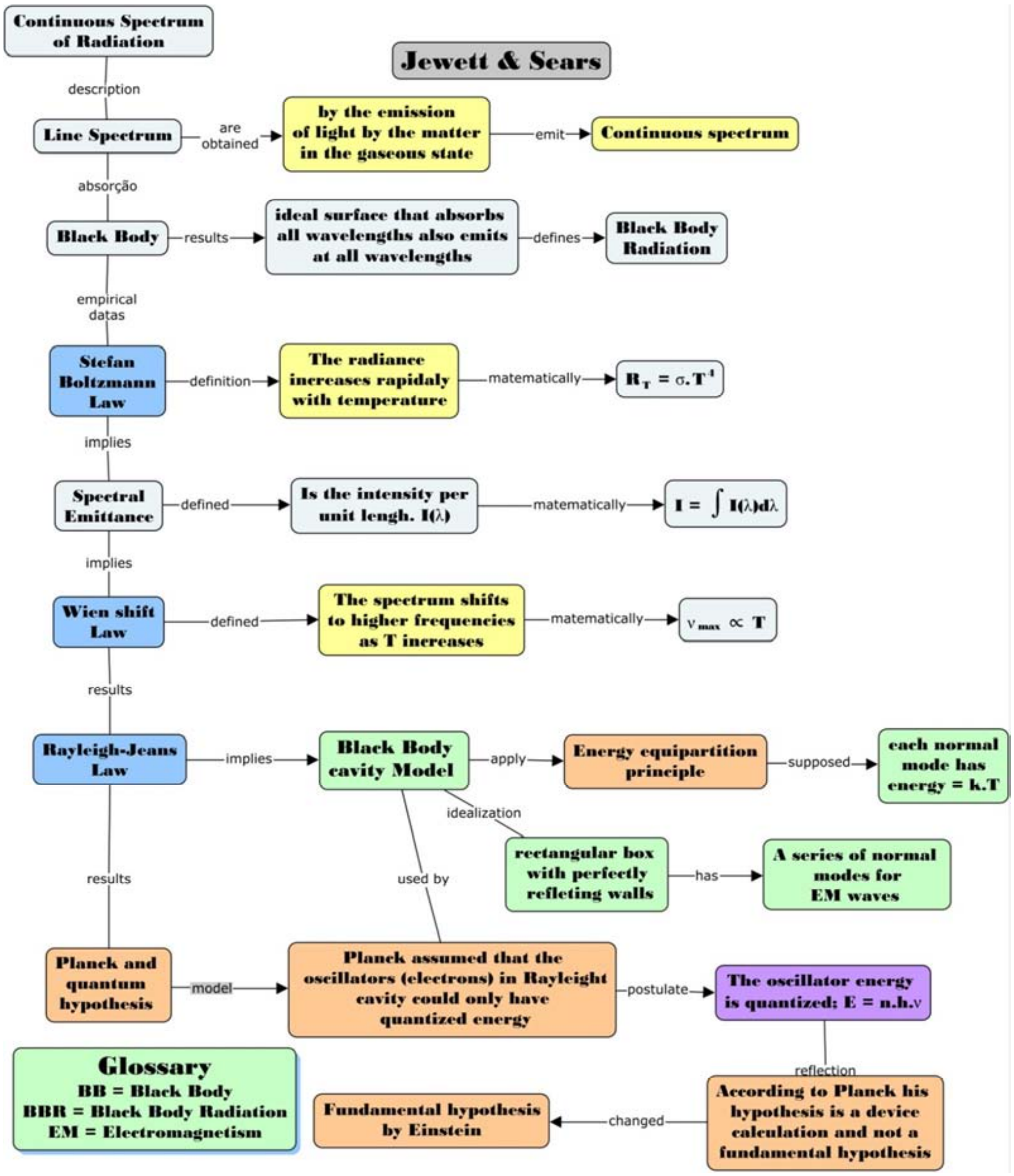

Figure 10. *MCA from the BBR Theory of Jewett-Sears text [23].*

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