Problem solving and writing II: The point of view of hermeneutics

Jorge Barojas[1, 2]

[1]*Department of Physics, School of Sciences. UNAM. Circuito Exterior, Ciudad Universitaria. A.P. 70542. C. P. 04510. México, D. F., México.*
[2]*Member of the Seminar on Hermeneutics, at the Institute of Research in Philology, UNAM.*

E-mail: jbarojas@posgrado.unam.mx

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Abstract

In this second paper we continue with the connections between problem solving and writing taking into accounts the perspective of hermeneutics. The problem solving protocol used in the first paper is modified in two cases: first to present the narrative of the solution provided by a writer to a physics system (the buoyancy of an iceberg) and second to approach the solution of a problem in a human learning system. As an example of the second system the development of a learning community in charge of a masters' program devoted to training high school teachers is discussed. Finally, some implications of human interactions occurring in the contexts of problem solving and communicating and interpreting are considered in Physics Education.

Keywords: Problem solving, Problem-based learning.

Resumen

En este segundo artículo continuamos con la relación entre resolver problemas y escribir, ahora desde el punto de vista de la hermenéutica. El protocolo de solución de problemas considerado en el primer artículo se modifica en dos casos; primero, para presentar la narrativa que haría un escritor respecto de la solución del problema de física de la flotación de un iceberg y luego, para abordar la solución de un problema en un sistema de aprendizaje humano. Como ejemplo ilustrativo del segundo sistema discutimos el desarrollo de una comunidad de aprendizaje que tiene a su cargo una maestría dedicada a la formación de profesores de enseñanza media superior. Finalmente, consideramos algunas implicaciones en enseñanza de la física de las interacciones humanas que se dan en los contextos de solución de problemas, comunicación e interpretación.

Palabras clave: Resolución de problemas, aprendizaje basado en problemas.

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I. COMMUNICATION AND INTERPRETATION IN PROBLEM SOLVING

We write documents by using symbolic representations under certain contexts with the goal of communicating something through reading or listening. The preparation, communication and interpretation of these intellectual products imply creative designs that are highly developed outcomes of thinking. These designs evolve into written texts containing discourses to be interpreted.

Written documents do not include details about the reasoning trajectories or patterns accomplished in the mind of the author; they report only what seems to be the better outcomes. However, the intention of the author must be clear and clean in a final product without ambiguity. In reading a written document two processes are of equivalent importance: the communication of a product and its interpretation.

Problem solving and writing are creative designs that have structural similarities corresponding to a plan proposed by the author. Such a plan must be grasped by the readers according to their interpretation approach. It is in this context that it might be useful to use instruments for interpreting written texts.

In paper I the roles of cognitive and metacognitive reasoning skills in presenting and evaluating the design, and the construction and communication of the solutions to problems have been interpreted in connection with conceptual activities, such as formation, treatment and conversion of semiotic representation registers [1]. We must remember that a representation register is any device for recording. In order to make clear how these two dimensions (cognitive and metacognitive) are related in problem solving and writing we have described a protocol or procedure called TADIR that was applied to explain the solution of a problem in a physical system (the problem of buoyancy). We have considered the approach of a physicist who uses three kinds of languages: the natural language of everyday talking, the technical language of Physics, and the formal language of mathematics.

In this second paper we deal with the same physics problem but describe what might be the narrative of the solution provided by a writer who uses the protocol TADIR with some modifications. Afterwards, we consider an adaptation of the same protocol TADIR to discuss the solution of a problem in a human learning system corresponding to a Physics Education program. The interpretation of possible solutions to both problems is done from the point of view of hermeneutics, the discipline concerning the interpretation of texts.

II. REMARKS ON HERMENEUTICS

The name hermeneutics is associated with Hermes: the Greek god of communication, the borders, the limits. It represents the crossing of paths and the coincidence of moments. Initially, hermeneutics was connected only to the comprehension and interpretation of written texts. In Plato, it was referred to inspiration and communication of messages, and in Aristotle it was conceived as a theory of expression [2]. Nowadays, the notion of text also includes dialogues, images and actions.

All interpretation assumes that the author of a text has some intentionality to be expressed within a context. It comprises what has been said, exists and is done at the moment of the production of the text. The plurality of possible interpretations is a consequence of the variability of contexts determining the readers´ approach and the comprehension that comes out from the interpretation of the text.

By following Grondin [3] interpretation has had meaning and manifestation forms in philology, art, translation, jurisdiction and in our presence in the world. The goal is to provide scenarios while looking for meanings in contexts where the interpreters act as mediators in a wide spectrum of perspectives. Different meanings can be interpreted in terms related to cognitive, ideological, historical or linguistic issues. We might refer to interpretations concerning human works or manifestation of nature in order to understand their structures and functions.

The interpretation of a text implies the comprehension of both a reference and a meaning. The reference is the concrete link with facts. The meaning is the mental construct that is apprehended when we understand something. The reference is unique when the meaning is clear and distinct and when there is no place for misunderstandings. The meaning is multiple when many forms of understanding the reference are valid and convincing. However, a reference without meaning is empty and meaning without reference is useless. We require a mediation process between uniqueness of consensus and diversity of dissension depending on having only one reference and meaning or many of both of them.

The main purpose of any author, as a writer or as a problem solver, is to generate written documents to be apprehended by the readers. In each case the final product is a concrete document that provides meaning and generates understanding by dealing with a set of questions that are presented, framed and answered. Questions and answers are interpreted depending on the meanings that the author wishes to accomplish among the readers. Scientists and engineers aim to create only one interpretation or the minimum possible options to avoid dispersion by making comprehensible the literal meaning of the text. Writers and poets in particular are more open to produce diverse interpretations of the allegoric meaning of their texts.

Analogic interpretations look for a balanced situation between the two extreme forms of reading a text: the literal reading which is unique and rigorous and corresponds to only one reference or the allegoric reading which is unbounded and multiple and represents many meanings [4]. The aim is to recuperate different possible meanings and to organize them according to a hierarchy of interpretations by supporting their corresponding meanings with appropriate references under concrete circumstances. In the case of the problem related to a physical system the literal reading is the most convenient for scientists and engineers because the reference is assumed to be clear and complete. However a writer narrating how the solution has been obtained might take advantage of the allegoric reading because several meanings might be appropriate due to more diverse references. In the case of a problem related to a human learning system like a project on Physics Education the interpretation of the text explaining the solution could contain an appropriate proportion of the allegoric reading of a writer’s viewpoint and the literal reading of the physicist’s approach.

III. THE SOLUTION OF A PHYSICS PROBLEM NARRATED BY A WRITER

Scientific documents reporting the results of problem solving follow macro-structures that contain elements such as: title, authors and addresses, abstract, introduction, methods, results, discussion, acknowledgements, and references. Sharples [5] defines a macro-structure as “a constraint that operates at a global level” in order to accomplish three purposes: to frame the style and content of the manuscript, to provide links between parts of the text and internal coherence of the whole, and also to organize the reader´s expectations. This author also considers that the cognitive engine of writing implies cycles of engagement and reflection; the final product of the interaction of these cycles is expressed as a written discourse in a given language.

Usually the structure of written documents reporting on the solution of problems in physical systems is similar to a written discourse: although it works in different domains and for different purposes, it is like a narrative or storytelling. Authors like Hoey [6], referring to Winter [7], mentions five constitution elements or items defining a written communication: situation, problem, solution, observation, and evaluation. Now we briefly describe the structure of the discourse prepared by a writer that takes into account these same five elements from the perspective of hermeneutics. We refer these elements to the cognitive and metacognitive dimensions of problem solving used in a modified TADIR protocol as well as to the cognitive activities of formation, treatment and conversion involved in semiotic representation registers.

A. The cognitive dimension of a writer's narrative of the solution of a physics problem

The TADIR problem solving protocol has two main characteristics [8]: (1) it makes possible paths explicit showing the reasoning process leading to the solution, and (2) it relates and enriches the two dimensions worked out in preparing the written communication: cognition and metacognition. Next, Table I shows an adaptation of this problem solving protocol to communicate a story serving to unfold the solution of the buoyancy problem previously considered in paper I. We assume that the five steps of TADIR are followed by a writer understanding Physics. As a natural language is employed to talk about Physics in here we have more possibilities for multiple interpretations of the text written by the author. Furthermore, representations forms, like equations and graphics, are seldom used in the text containing such a narrative of the solution.

TABLE I. Solution of a physics problem from a writer's perspective

Elements of the narrative	Characteristics of each element	Narrative of the writer
Situation	An initial step in the description is entirely written in a natural language.	*We consider that a piece of ice called iceberg is floating on water.*
Problem	The question to be answered is explained in a natural language but some technical terms are introduced.	W*e want to calculate how much of the iceberg is over the surface level of water (the floating volume) and how much is submerged in water (the sunk volume).*
Solution	The solution is presented by describing the chain of reasoning steps required for obtaining an answer and theoretical considerations and references to ancillary knowledge are given by using the technical language of the corresponding discipline.	*We assume that the iceberg is in equilibrium due to the balance of two forces: the downward weight of the iceberg and the upward buoyant force (thrust) which is due to the weight of an amount of water equal to the volume of ice that sinks (this is known as Archimedes´ Principle).*
Observation	Some remarks are made in a natural language concerning the physical conditions of the system under consideration and conceptual requirements are expressed by introducing specific terms of common use in the technical language of the discipline of Physics.	*We take into account that size (volume) and density of the ice characterize the iceberg, that water has a different density than ice, and that the air does not matter. Furthermore, we need to know the relationship between weight and mass, and the definition of density in terms of mass and volume.*
Evaluation	The description of the declared procedure to solve the problem is finally made in a natural language. The aim is to verify that a correct and complete answer has been obtained.	*As we can get the values of the densities of ice and water, we calculate the numerical value of the ratio of the part of the iceberg that floats with regard to the part that sinks.*

Now we propose three connections between the steps of the TADIR protocol followed by the physicist (Table 1 in paper I) and the elements of the narrative proposed by the writer previously described. In each case we also indicate the corresponding transitions between the four stages (S_1 to S_4) of the learning cycle described in paper I, and those relationships that can be established in connection with the three conceptual activities concerning semiotic registers (formation, treatment and conversion).

(1) The components of the narrative describing the *situation* and the *problem* are associated with both the Translation and the Analysis steps in TADIR. In here the conceptual activity of formation of registers refers to the knowledge of the basic concepts of floating and sinking. To start the problem solving procedure the following transition from S_1 to S_2 is accomplished: first, the statement of the problem is described by using everyday natural language (S_1) and the world views of the writer interpreting the scenario of the physical system are presented in the technical language characteristic of the discipline (S_2).

(2) The *solution* component corresponds to the Design step in TADIR, mainly by describing the basic idea solving the problem (Archimedes´ Principle). The understanding of this principle implies the conceptual activities of treatment of those registers corresponding to the key concept of equilibrium of two forces: the downward weight of the iceberg originating the sinking which depends on the entire volume of the iceberg, and the upward buoyant force or thrust responsible for the floating which is due to the weight of the water displaced by the volume of the iceberg that is submerged. In this step the transition is from S_2 to S_3: after analyzing a problematic situation in abstract terms serving to

describe possible scenarios that might lead to the solution of the problem (S_2), theoretical model structures are applied through the use of formal languages that lead to the presentation of a design of the solution (S_3).

(3) Aside basic concepts, the two other kinds of knowledge elements utilized in the Design step are conceptual relationships and ancillary calculations. These two elements are related to the components of *observation* and *evaluation* and are integrated into the Implementation step of TADIR. The conceptual activity of conversion between the registers related to floating and sinking implies that each one of these registers has been previously developed at the level of treatment and that changes of representations have been accomplished. This step corresponds to a transition from S_3 where formal languages are used to S_4 where changes among different representation registers are performed. This transition requires the use of physical concepts and conceptual relationships such as density, mass, volume, weight and the acceleration of gravity, in order to be able to get the solution of the problem.

B. The metacognitive dimension of a writer's narrative of the solution of a physics problem

In this section we consider what could be presented by a writer reviewing (R) the four elements (TADI) of the problem solving protocol: R_T, R_A, R_D, and R_I. We comment on possible recommended actions to be undertaken by a writer willing to clarify from the hermeneutic perspective the reasoning process behind the communication made in a natural language. We assume that the writer reflects again on the two key elements defining the text to be interpreted: the reference (mainly through R_T and R_A) and the meaning (mainly through R_D and R_I). The four components of the last step of TADIR might have the following purposes:

- Concerning the Review of the Translation Step (R_T).

Examine the style or form of the written text used in explaining the S*ituation* that describes the *Problem* and relates to the conceptual activity of formation of the required registers. Make sure that the written communication satisfies the 4C criteria that characterize an appropriate use of natural language and avoid wrong interpretations: the written text is clear, complete, correct and concise.

- Concerning the Review of the Analysis Step (R_A)

Ponder the arguments in favor or against what has been written while reconsidering the assumptions made to solve the problem. This means to work more on the conceptual activity of treatment of the corresponding semiotic registers associated to the concepts of floating and sinking. It also refers to the evidence showing that the answers provided by the *Solution* fully respond to the questions addressed in the statement of the problem.

- Concerning the Review of the Design Step (R_D).

Observe the presence and the functioning of different elements intervening in the communication of the discourse describing the solution and regard how the conceptual activity of conversion leads to the solution of the problem. Consider the use of literary resources such as the employment of metaphors, analogies, catalysts…

- Concerning the Review of the Implementation Step (R_I).

Evaluate the initial plan for writing, compare with the final results and look for possibilities of improvement. Work on the interrelationships among the three conceptual activities relating semiotic registers (formation, treatment and conversion) and on the impact on the efficiency of the communication process that might involve factors such as patterns, insight, elegance, power, and style [5].

IV. PROBLEM SOLVING IN A HUMAN LEARNING SYSTEM

Educational projects are planned and developed in a cognitive space associated with the intersection of two intellectual domains that characterize human learning systems: the building of knowledge and the organization of learning [9]. Human learning systems comprise planning, development and evaluation oriented towards promoting and coordinating learning processes in which the creation of learning communities (LCs) is fundamental. These LCs are interacting groups aiming to mainly accomplish four goals: to be informed, to organize communications, to obtain and apply knowledge, and to accomplish transformation tasks for specific purposes such as problem solving, decision making or system design. From the working point of view, LCs involve actors and resources in order to provide services, organize projects, lead processes and make products available. In order to succeed, LCs need technology and knowledge management. LCs must serve to develop self-learning skills, to wisely apply information, to promote innovation, and to improve competitiveness; briefly, to build and manage relevant knowledge [10].

In what follows we apply the TADIR problem solving protocol adapted to a human learning system and describe first and second order approximations to the solution of this problem: how can we understand and improve the functions of an LC in charge of a masters' program focused on the education of high school teachers?

The educational program in which we are interested is called MADEMS, which stands for the initials of its title in Spanish: **MA**estría en **D**ocencia para la **E**ducación **M**edia **S**uperior (Masters' Degree Program for Teacher Education at the High School Level). This is a multidisciplinary two-year program that started in February 2004 at Universidad

Nacional Autónoma de México and comprises learning activities focusing on education as well as on the teaching of different disciplines. Up to now the program includes the following disciplines: Biology, Chemistry, History, Mathematics, Philosophy, Physics, Social Sciences, and Spanish. In the near future Classical Letters, English, French and Psychology will be incorporated. More details can be found in the web page of the program: http://www.posgrado.unam.mx/madems/index.html.

In order to solve our problem, which means to explain how our LC is organized, we now apply the TADIR protocol adapted to a human learning problem by making each one of its five steps explicit.

TRANSLATION (T): interpret the context of the problem in terms of the elements defining the LCs and the transformational activities in which they are involved.

The LC that deals with the MADEMS educational program is integrated by five working groups (WG) each one of them outlined as follows:

WG1 – Direction Group: the directors of the schools, centers and institutes that participate in the program; their representatives, as well as representatives of tutors and of students.

WG2 – Operation Group: the general coordinator of the program and assistants in charge of planning, follow-up, accounting, and information.

WG3 – Education Group: professors who organize courses and tutors who lead the dissertation projects of the students.

WG4 - Administration Group: registrars in charge of logistics and staff responsible for registration and students´ follow up.

WG5 – Student Group: people taking courses and working towards graduation in two forms: attending lessons or getting instruction in distance education.

Our LC is active in five transformational activities (TA) to which specific groups indicated in parentheses correspond: TA1 – organization (WG1 and WG2), TA2 – coordination (WG2 and WG4), TA3 – teaching (WG2, WG3, WG4 and WG5), TA4 – control (WG2 and WG4) and TA5 – production (WG3 and WG5).

ANALYSIS (A): provide the explicit characterization of the working conditions of the system.

This second step is defined in terms of the following aspects that define how the LC works: objectives, limitations, performance criteria, production of materials, decision making procedures and connectivity arrangements related to the use of information and communication technology (ICT).

DESIGN (D): propose *a first order conceptual model describing the agents and their main tasks required to solve the problem.*

In this third step, the working groups previously indicated deal with specific transformation activities (TA). Fig. 1 is a graphical representation of the interactions among agents, tasks, and resources required to solve the problem. This is a first order conceptual model that does not provide final solutions; it is just a schematic description of a possible path indicating how the LC might approach the problem.

IMPLEMENTATION (I): report on results obtained after working on each TA by applying monitoring and control mechanisms.

In this fourth step two mechanisms are applied to clarify if there is evidence showing advances or requiring adjustments in the operation of the LC. The first mechanism is monitoring and it is defined by the four elements related to the FODA methodology. FODA or SOWT stands for Fortalezas (Strengths), Oportunidades (Opportunities), Debilidades (Weaknesses) and Amenazas (Threats) [11]. Strengths (Weaknesses) refer to activities accomplished with high (low) degree of efficiency, and Opportunities (Threats) concern those events that help (hinder) the attainment of objectives. In principle, as the project makes progress, Weakness and Threats must disappear or be transformed, respectively, into Strengths and Opportunities.

The second mechanism is control and it is related to the application of rubrics [12] designed to evaluate the performance of the agents forming the five working groups that belong to the LC. This is made in connection with the following four pragmatic pedagogical principles [13] adapted to our LC from those defined for science education: Make knowledge management accessible, Make thinking visible, Help LC members to learn from each other, and Promote lifelong learning among LC members.

REVIEW (R): reconsider the previous four TADI steps and go further into higher order conceptual models of the solution.

This last step is of metacognitive nature and implies rethinking procedures and work produced by the LC in order to get successively better solutions to the original problem: how can we understand and improve the functions of an LC in charge of a Masters' program focused on the education of high school teachers?

In order to get a second order conceptual model, each transformational activity is considered as a subsystem by indicating what kind of actions and results can be considered as documented evidences in connection with the tasks related to each TA; also corrective plans and additional support procedures can be incorporated. This review process is shown in Fig. 2 and detailed in Table 2.

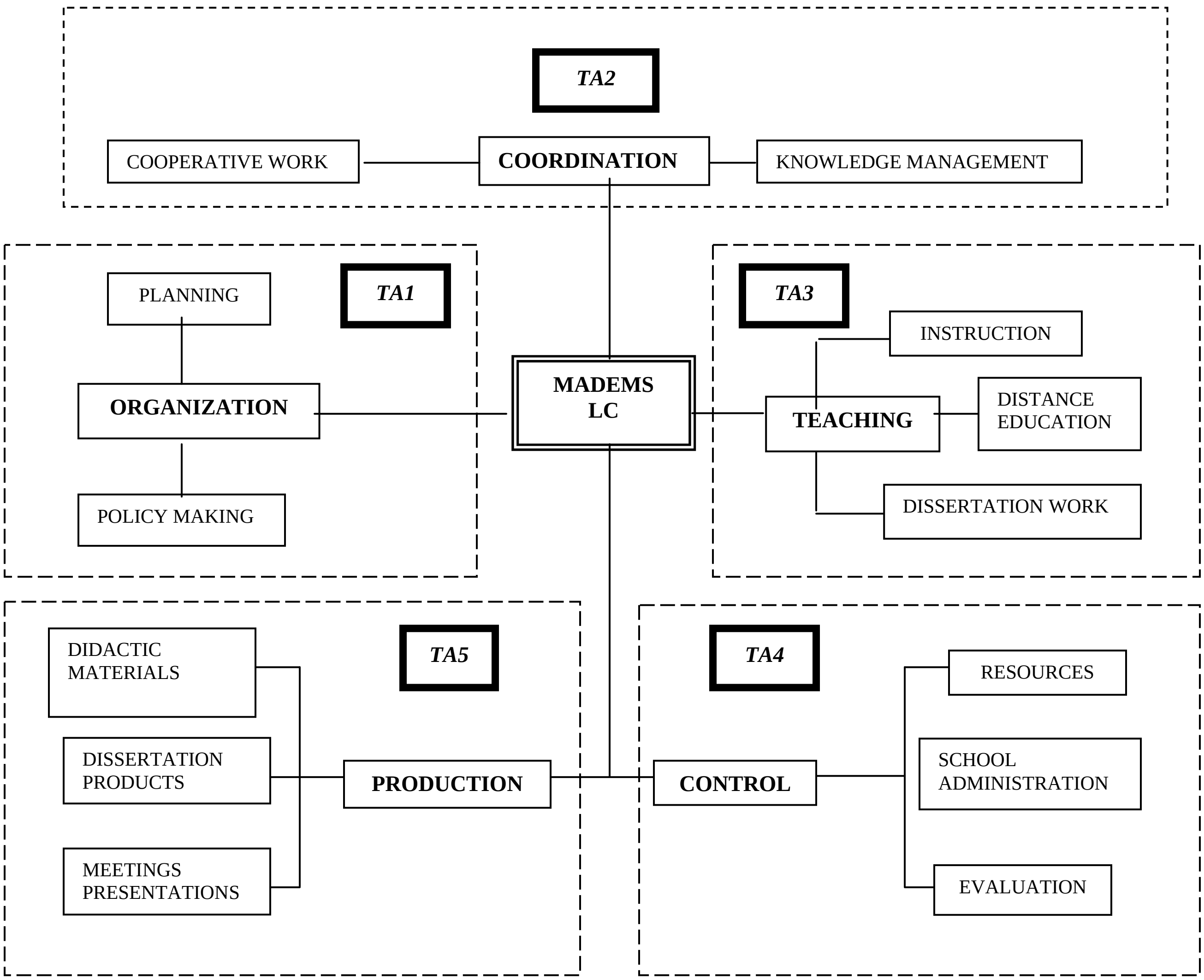

FIGURE 1. First order conceptual model of the learning community (LC) in charge of MADEMS.

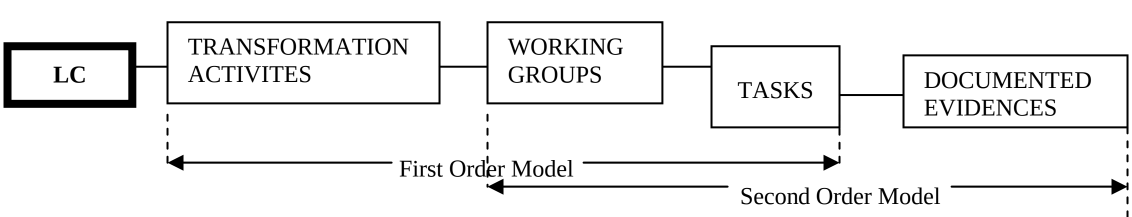

FIGURE 2. First and second order conceptual models of the learning community (LC).

TABLE II. Content of a second order conceptual model

TRANSFORMATION ACTIVITIES	TASKS	ACTIONS PROVIDING EVIDENCES
***TA1* ORGANIZATION**	PLANNING	Approve and follow up working plans. Promote connections and obtain grants.
	POLICY MAKING	Provide orientation and make recommendations. Pursue both vision and mission of the program.
***TA2* COORDINATION**	COOPERATIVE WORK	Define objectives and goals. Promote efficiency in working groups.
	KNOWLEDGE MANAGEMENT	Use information and improve knowledge in LC. Prepare reports, talks and study cases.
***TA3* TEACHING**	INSTRUCTION	Define learning competences and contents. Organize cognitive activities and evaluations.
	DISTANCE EDUCATION	Prepare test and use didactic materials. Train and support teacher assistants.
	DISSERTATION WORK	Define dissertation topics and products. Guide students to finish in form and time.
***TA4* CONTROL**	RESOURCES	Distribute budget and equipment.
	SCHOOL ADMINISTRATION	Organize admissions and time schedules. Evaluate and support teaching performance.
	EVALUATION	Detect strengths and weaknesses. Guarantee quality and pertinence.
***TA5* PRODUCTION**	DIDACTIC MATERIALS	Produce, test, improve and publish materials.
	DISSERTATION PRODUCTS	Guide and publish the work of students.
	MEETINGS PRESENTATIONS	Document and communicate the participation of students reporting on their dissertation projects.

V. INTERPRETING WRITING AND PROBLEM SOLVING IN PHYSICS EDUCATION.

The human learning problem previously considered offers plenty of texts to be interpreted due to the complexity of the interactions among the actors of the program and their transformational activities and products. What follows is a summary of the applications of the TADIR problem solving protocol both from the points of view of Physics and of hermeneutics:

(1) In order to communicate and interpret texts for learning purposes, two issues are important: what concepts are presented and how they are registered and used according to different re-presentations. By following Duval [14], natural languages are the most appropriate representation registers to begin and to close learning processes. This author specifically refers to mathematics, but we have extended his consideration to other disciplines, as well as to deal with human learning systems where plans, processes, projects and products are different from those occurring in physical systems.

(2) The same conceptual object or event can be registered in terms of different representations conveying partial descriptions of the total object or event. These representations acquire meaning and are registered according to the circumstances in which those representations are used by the author and interpreted by the readers of the text.

(3) In order to help students or any other reader to handle different representation registers and to develop expertise in building knowledge that is applied in problem solving, teaching must provide and co-ordinate learning activities that facilitate conversions from natural languages into technical and formal languages, which also means to acquire mastery in changing or transferring among the corresponding representation registers.

(4) Texts in natural languages are more exposed to differences in readers´ interpretations than texts mostly containing expressions in technical or mathematical languages, once readers are familiar with those languages. This means that problems related to human learning systems might imply more diverse interpretations than problems in physical systems.

(5) There are limits or normative constraints on the use of any language, like grammar, style, and the conceptual structures of the discipline(s) involved in each case. Anyhow, we assume that creators of texts are capable of handling those constraints and can show in their results a fertile integration of planning, inspiration and expertise.

In Physics Education, the authors of the texts to be interpreted correspond to teachers and students, as well as to authors of textbooks, didactic materials, curriculum development programs and educational projects. However, it is an oversimplification of the teaching process if we assume that corresponding authors (teachers and students) consider and follow in a straightforward manner and in a rigid order the steps of the TADIR protocol or the steps of the learning cycle. The discursive practices implied in teaching procedures might involve conceptual activities regarding the semiotic representation registers considered in the learning cycle. This could imply that different possible interpretations given by the students are approximations to what teachers say and do by using different languages. Also that the teachers need to be aware of differences between the interpretation conveyed by instruction and the interpretations attained by the learners.

Any approach to Physics Education from the perspective of hermeneutics does not look for universal interpretations imposed by the authority of the teacher, the text book or the program schedule. Being able to accept other options is useful in order to understand the learners and authors in terms of schools of thought, time periods, intellectual works, human needs, social requirements,… Such a fruitful interplay among interpretations will be particularly rewarding as a culmination of the teaching contextualization procedure [15] which consist of three steps related to each one of the conceptual activities involved in the use of semiotic representation registers: (1) start by presenting a problematic situation in connection with the conceptual activity of formation, (2) focus on answering some leading questions implying the conceptual activity of treatment of registers, and finally (3) close with learning activities in which the conceptual activity of conversion among registers is explicitly undertaken.

Communicating and interpreting the solutions of problems in physical and human learning systems requires understanding different languages. This intellectual need concerns those typological and topological aspects characterized by Lemke as verbal and visual representations integrating what he calls “multimedia semiotics” [16]. According to this author writing concerns a “visual graphological-typographical semiotics”. However there are other “modes of meaning-making” going beyond speech and writing like for instance drawings, gestures and motor activities which he refers to as “graphical-operational-topological semiotics”. It is in this sense that the TADIR problem solving protocol can be understood as an interpretation instrument working in the domains of typographical and topological semiotics.

We are persuaded that connecting the advantages of using ICT with the cognitive and metacognitive demands of problem solving and writing from the perspective of hermeneutics can improve important issues such as the following: the creativity and efficiency in teaching and learning, particularly on line [17], promote and orient research on the didactics of science and technology [18], and make new intellectual tools and products available to problem solvers as designers working collaboratively [19].

We close this paper by referring again to Sharples [5] who reported the observation made by Pennington [20] concerning the presence of four stages in the development of children expertise using word processors: (1) after initial training children start writing easier, (2) they produce more written works, (3) after a while a qualitative change occurs when they write differently, and (4) finally they do better by adopting a cycle of composing, reflecting and revising. We do believe that the same performance chain occurs in problem solving (easier, more, different and better), through the integrated use of hermeneutical perspectives dealing with the cognitive and metacognitive activities incorporated in the learning cycles and interpreted in terms of natural, technical or formal languages connected with typological and topological semiotics. We are also convinced that in order to make that happen, educational contexts must provide students and teachers with the appropriate means and tools that improve discursive practices and their interpretations. The price of going into this complex process is time, understanding and patience; however, there is a net reward concerning the learning outcomes achieved by students.

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REFERENCES

[1] Barojas, J., *Problem solving and writing I: The point of view of Physics*, Lat. Am. J. Phys. Educ. **1**, 4-12 (2007).
[2] Ferraris, M., *Historia de la hermenéutica* (Siglo XXI, México, 2005).
[3] Grondin, J., *Qu´est-ce que l´interpretation?,* Skepsis, 127-132 (2004). Also in <http://www.philo.umontreal.ca/prof/documents/Interpretation2004.pdf>, Oct. 2007.

[4] Beuchot, M., *Tratado de hermenéutica analógica* (UNAM – Itaca, México, 2001).

[5]. Sharples, M., *How we write* (Routledge, London, 1992).

[6] Hoey, M., *Signalling in Discourse. English Language Research* (University of Birmingham, Birmingham, UK, 1979).

[7] Winter, E. O., *A clause-relational approach to English texts; a study of some predictive lexical terms in written discourses*, Instructional Science **6**, 1-92 (1977).

[8] Barojas, J., *Teacher training as collaborative problem solving*, Educational Technology and Society **6**, 1-10 (2003)

[9] Barojas, J., *Comunidades de Aprendizaje y organización del conocimiento.* In XVIII Simposio Internacional de Computación en Educación, SOMECE (Eds.), Zacatecas, México. In compact disc (2002).

[10] Barojas, J., Sierra, J. and Martínez, R., *Application of a knowledge management network in distance education*. In A. Méndez-Vilas, A. Solano Martín, J. Mesa González and J.A. Mesa González (Eds.) Current Developments in Technology-Assisted Education. V Conferencia Internacional sobre Multimedia y Nuevas Tecnologías de la Información y la Comunicación en Educación (m-ICTE2006), FORMATEX, Badajoz, Spain, Annex, 11-16 (2006).

[11] Instituto Politécnico Nacional, Secretaría Técnica, *Metodología para el análisis FODA* (2002), <http://www.uventas.com/ebooks/Analisis_Foda.pdf>, Oct. 2007.

[12] Picket, N. and Dodge, B., *Rubrics for Web lessons* (2007). Available in: <http://edweb.sdsu.edu/webquest/rubrics/weblessons.htm> Oct. 2007.

[13] Linn, M. C. and Hsi, S., *Computers, Teacher, Peers: Science learning partners* (Lawrence Erlbaum Associates, Mahwah, New Jersey, USA, 2000).

[14] Duval, R., *Registres de répresentation sémiotique et functionement cognitif de la pensée* (Registers of semiotic representations and cognitive functioning of thinking), Annales de Didactique et de Sciences Cognitives **5**, IREM Strasbourg, France (1993).

[15] Barojas, J. and Dehesa, N., *Mathematics for Social Scientists: Learning Cycles and Teaching Strategies.* Industry and Higher Education **15**, 269-277 (2001).

[16] Lemke, J. L., *Multiplying Meaning: Visual and Verbal Semiotics in Scientific Text*. In Martin, J. R. and Veel, R. (Eds.), *Reading Science* (Routledge, London, UK, 1998) pp. 87-113.

[17] Harasim, L., Hiltz, S., Teles, L. and Turoff, M., *Learning Networks. A guide to teaching and learning on line* (MIT Press, Massachusetts, USA, 1995).

[18] Lijnse, P., *Didactics of science: the forgotten dimension in science education research?* In Millar, R., Leach, J. and Osborne, J. (Eds.), *Improving Science Education. The contribution of research* (Open University Press, Philadelphia, USA, 2000) pp. 309–326.

[19] Jones, P. M., *Collaborative Knowledge Management, Social Networks, and Organizational Learning.* In Smith, M. J. and Salvendy, G. (Eds.), *Systems, Social and Internationalization Design Aspects of Human-Computer Interaction* (Lawrence Erlbaum Associates, Mahwah, New Jersey, USA, 2001) vol. 2, pp. 306-309.

[20] Pennington, M. C., *Writing the natural way on computers,* Computer Assisted Language Learning, **9**, 125-142 (1996).