

# **Discourse analysis as a tool for the transformation of teachers' talk companion meanings about NOS, NOT and NOL**

PILIOURAS Panagiotis, KOKKOTAS Panagiotis, Department of Primary Education, University of Athens, Greece

[ppiliour@primedu.uoa.gr](mailto:ppiliour@primedu.uoa.gr), [kokkotas@primedu.uoa.gr](mailto:kokkotas@primedu.uoa.gr)

## **Abstract**

Our paper refers to a collaborative action research that concerns the gradual transformation of the nature and type of teachers' talk in more collaborative inquiry conditions in three elementary science classrooms. The basic strategy in order to accomplish this goal was to give the chance to teachers to analyze their own talk using a three-dimensional discourse analysis descriptive context. Teachers analyzed their own talks about aspects of their own teaching practices namely: companion meaning about the Nature of Science (NOS), the Nature of Teaching (NOT), and the Nature of Language (NOL). Our research indicated that the involvement of teachers in analyzing their own talks led in the transformation of the social interactions in science classrooms. Gradually the companion meanings that were created implicit or explicit from the dialogues that were taking place in the three science classrooms were more appropriate for the establishment of more desirable collaborative inquiry conditions. The discourse analysis tool provided teachers with a meta-didactical awareness of the learning and teaching processes.

**Keywords:** discourse analysis, companion meanings, Nature of Science, Nature of Teaching, Nature of Language, teachers as researchers, meta-didactical awareness

## **Introduction**

This paper refers to a collaborative action research program of two researchers and three teacher-researchers. Nowadays, the theoretical frameworks underpinning the views of learning, language and cognition gradually have shifted from a personal constructivist views towards more socio-cultural ones (e.g. Lemke, 2001; Wells, 1999). The “cultural” turn (e.g. Bruner, 1996) in psychology has involved a shift in focus away from viewing meaning-making exclusively in terms of cognitive processes in the individual, towards an account of individuals as they function in social contexts (Leach & Scott, 2003). In the heart of sociocultural approaches, in both theory and practice, is the collaborative and transformative way in which knowledge is co-constructed (learning as collaborative inquiry, e.g. Wells, 1999). As Rogoff (2003) supports “thinking is collaborative and distributed among people in shared endeavors” (p. 281). In our work, we adopt the sociocultural position that the learning process can be viewed and studied as an activity system (Engeström, 1999) and learning of science as appropriation-transformation through participation in gradually evolving and appropriately guided discourses and practices (e.g. Rogoff, 2003; Lemke, 2001; Gee, 1999).

## **Companion meanings and Science Education**

The purpose of the action research program was the gradual transformation of the elementary science classrooms of the three teacher-researchers to a more collaborative inquiry conditions (e.g. Wells, 1999). In our effort in order to establish more collaborative inquiry conditions during science lessons, we adopted a discourse analysis oriented procedure that presupposed the active participation not only of the researchers but also of the three teacher-researchers in the analysis of teacher-students talk. A basic strategy, in order to accomplish this goal, was to give a chance to teacher-researchers who participated in the research program, to analyze their own talk using a

three-dimensional discourse analysis descriptive context related with the companion meaning about Nature of Science (NOS, e.g. Matthews, 1998; McComas et al, 1998; Lederman, 2007), Nature of Teaching (NOT, e.g. Yerrick & Roth, 2005; Wells & Claxton 2002), and Nature of Language (NOL, e.g. Sutton, 1998, Scott, 1998) that were created from their talk during science lessons. Roberts and Östman (1998) refer to *companion meanings* to describe the different layers of explicit and tacit messages about power, status, method and ontology communicated through the science curriculum. Companion meanings accompany scientific meaning in science education, and these can be either deliberately planned and incorporated in teaching (as with curriculum emphasis) or “unintentional” (Roberts & Östman, 1998) (e.g. teachers views about NOS, NOL and NOT that are in accordance or not with the aims of the official curriculum).

As Ostman (1998) argues companion meanings are located in ongoing science classrooms discourses. In our opinion a basic agent of the companion meanings that are communicated to students in science lessons is the teacher himself. Based on the sociocultural driven positions and theoretical constructions we can conclude that the discursive practices of a learning environment in which students participate are fundamental for the type and nature of their learning (e.g. Brickhouse, 1990; Lemke, 1995; Gee & Green, 1998). We support that the nature and type of talk science teachers contribute in the learning procedure is of fundamental importance in establishing a collaborative inquiry environment. Companion meanings are determinative for the learning of the students about the NOS, the NOT, and the NOL. In this context science education can be viewed in the light of an ongoing struggle over what knowledge and world view students are to be offered. The effect of this struggle is that certain knowledge is chosen, while other alternatives are excluded.

### **Problems with companion meanings that are communicated from science teachers’ discourses**

Research studies confirm a lack of understanding of science and its nature from the students and therefore a mysticism exists concerning the science and its knowledge (Driver et al, 1996; Lederman, 1992). Even today the field of science education is known as a subject which most students find difficult, and which too many find alienating (e.g. Fensham, 2002; Hurd, 1997). Studies have shown that high school science students and in-service teachers’ views of the NOS are not consistent with current accepted definitions of it (Lederman, 1992; Ryan & Aikenhead, 1992; Driver et al., 1996; Leach et al., 2000; Lederman, Wade, & Bell, 1998; Akerson, Abd-El-Khalick & Lederman, 2000). Bartholomew et al (2004) state:

*“...Another fundamental difficulty identified by a variety of authors is that many science teachers themselves are the products of an archetypal education which has largely ignored the epistemic base and nature of its own ....”*

The sociocultural perspectives provide as useful explanation for these major problems. According to the activity theory there are deep constraints and built-in obstacles in the establishment of a collaborative inquiry learning environment in a “science classroom” activity system. One of these constraints has to do with the undesirable companion meanings that implicitly or explicitly are communicated from science teachers discourses.

Lemke asserts that a major reason that leads students in alienation from science is the way teachers talk science, that is to say the nature of teacher’s language. As he argues “the language of classroom science sets up a pervasive and false opposition between a world of objective, authoritative, impersonal, humorless scientific fact and the ordinary, personal world of human uncertainties, judgments, values, and interests” 1990, p. 129-30). Gutierrez et al (1995) describe

this model of education as one where the teacher plans and orchestrates classroom interaction (the teacher script) and the students' options are to comply (support the teacher's script) or resist (develop a counterscript). Taylor (1994) suggests that science teachers have generally been inducted into the hegemonic discourse of science education and do not have the cultural resources or social support to enact the science curriculum differently, despite their best intentions.

Consequently a major reason for the difficulty to establish a desirable collaborative inquiry environment in science teaching classrooms is, as Taylor, Lemke and others claim, - and we have ascertained in our research - that teachers with their talk present monologic and authoritative views about NOS, NOT and NOL.

### **Discourse analysis as a metadidactical transformative tool**

In the past two decades, the study of discourse, driven from sociocultural orientations, has become an important theoretical perspective for those concerned with the study of learning in social settings (e.g. Lemke, 1995; Wertsch & Toma, 1995; Hicks, 1996; Gee, 1999). By studying discursive activity within science classrooms, researchers have provided new insights into the complex and dynamic relationships among discourse, social practices, and learning (e.g. Mortimer & Scott, 2003).

Wertsch (1991) regards conscious reflection as an important element in development within mediated action. In our research we tried to turn into praxis the orientated towards discourse analysis suggestion that critical reflection on our habits of meaning-making enlarges our universe of possible action (Lemke, 1995; Gee & Green, 1998).

Based on this context we argue for the necessity teachers to study the companion meanings created by their own talk. We see as very valuable in this direction the use and exploitation of discourse analysis process as a teachers' training and meta-didactical tool. An important feature of focusing on teachers' discursive repertoires and involving them in the discourse analysis procedure is encouraging them to develop dexterity in determining which approach from their repertoire is appropriate under which circumstances (Gutierrez & Rogoff, 2003).

### **The identity of the research**

We conducted a collaborative action research program in which two researchers and three teacher-researchers participated in the action research. The program aimed to create more collaborative inquiry conditions in three elementary science classrooms. We tried to develop the conditions creating learning environments where will take place creative hybrid dialogues and language games that facilitate communication and coordination during the participation of all the members of the science classroom communities. According to our approach meaningful dialogical engagements in science lessons might occur, within a discursive space that is itself more open to question and negotiation.

The basic strategies that we have implemented in order to accomplish our aim were the following:

- a) The explicit negotiation of communicative/ground rules when children were engaged on tasks requiring collaborative group work
- b) Analysis of teachers' talk by teachers themselves
- c) Analysis of peer group talks by the teachers
- d) Analysis of peer group talks by the students themselves

The question we investigated was the following:

Could an action research program that involves teachers in researching and analyzing their own discourse practices, lead to the transformation from mainly monologic modes of discourses that take place in elementary science classrooms to more dialogic ones?

## Collaborative action research

Aim

The establishment of a collaborative inquiry learning environment

*Training as interpretive and collaborative inquiry*

T1\* T2 T3

- Familiarization with research literature about collaborative inquiry and teacher-students interaction
- Familiarization with the methodology of action research and the developmental work research
  - Participation in the research process – discourse analysis by teachers themselves
- Amelioration of the existing – and design and implementation of new teaching strategies
- Design of learning activities

Teaching and learning as a collaborative inquiry mode and a dynamic process of progressive appropriation of science discourses and practices

\* T1 is for teacher

Our study took place in three Greek elementary science classrooms comprising 64 children (aged between 11 and 12) - for over a 2-year period. In all the classes the students worked in teams from the very start of the program. The learning situations in which the students worked were oriented to collaborative problem solving and inquiry tasks. Data were collected through field notes, videos of the teachers' lessons, and teachers' reflective diaries. Additionally the researchers occasionally interviewed students and teachers. The verbal interaction of the three classrooms were video recorded several times throughout the study. Overall we collected and transcribed 24 videotaped lessons that we divided in smaller activity instances.




In our research teacher-researchers with the guidance and the cooperation of the researchers made productive use of a series of discourse tools. In this paper we present the analysis of teachers' talk by the teacher-researchers themselves (with the guidance of the researchers) with the exploitation of a three dimensional context of analysis. This descriptive context is based on "*The 5 Dimensions of Practice*" of Bartholomew et al (2004).

*"...we argue that there are five critical dimensions that distinguish and determine a teacher's ability to teach effectively about science. Whilst these dimensions are neither mutually independent nor equally important, they serve as a valuable analytical tool for evaluating and explaining the success, or otherwise, that individual teachers of science have when confronted with teaching aspects about science... It is not intended or imagined that we will be able to place each teacher at a particular position along each dimension and that they will stay there; we have found these dimensions of teacher practice to be a useful tool for distinguishing teachers, and for thinking about salient features of the lessons we observed."*

Bartholomew et al (2004)

We, based on this tool ("*The 5 Dimensions of Practice*"), focused on three aspects of companion meanings (Table 1) that can be created from the talk of a science teacher, that is companion

meanings about the NOS, the NOT and the NOL. As we can see in the table 1 a teacher’s talk can communicate a variety of companion meanings about NOS, NOT and NOL.

| <b>Table 1: Teacher’s talk companion meaning - A three dimensional context of analysis</b>                                                         |                                                                                   |                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------|
| <b><i>Companion meanings about the Nature of Science (NOS)</i></b><br><b><i>Teacher’s knowledge and understanding of the Nature of Science</i></b> |                                                                                   |                                                            |
| One-dimensional -empiricist<br>view of NOS                                                                                                         |  | Pluralistic view of NOS                                    |
| <b><i>Companion meanings about the Nature of Teaching (NOT)</i></b><br><b><i>Teacher’s views of their own role</i></b>                             |                                                                                   |                                                            |
| Dispenser of knowledge<br>Closed and authoritative                                                                                                 |  | Facilitator of learning<br>Open and dialogic               |
| <b><i>Companion Meanings for the Nature of Language (NOL)</i></b>                                                                                  |                                                                                   |                                                            |
| A system of transmitting<br>information                                                                                                            |  | An interpretative system for making<br>sense of experience |

### **Findings - Initial Phase: A Monologic Discourse**

The study and analysis of data that we made with the active participation of the teacher-researchers indicated that before they get familiar with and develop the proper theoretical and practical background, they have difficulties to cultivate a collaborative learning environment, and a dialogic mode of meaning making in their science lessons.

Afterwards we present, with the use of the three dimensional context, the analysis from a teacher-researcher of a characteristic dialogue that took place in his science lesson from the initial phase of the program. The extract that precedes of the analysis is from the teaching of the concept of friction in the fifth grade in an elementary school in Athens. Students had to do the experiment to measure the friction using different materials. They used in the experiment sandpaper, plasticine, and oiled surface.

Extract 1: December 14, 2003 (5<sup>th</sup> grade, “Friction in our lives”)

*Teacher: You? (addressing the fifth team)*

*Student (as team representative): We have found that the sandpaper is 75, the plasticine is 75, and also the oil.*

*Teacher: Also the oil? (vigorously)*

*Student: Err, yes.*

*Teacher: Didn’t the surface change?*

*Student: Err, yes.*

*Teacher: What should you have found then? Less or more?*

*Student: Less*

*Teacher: Less? But we do not know how much. This means you have made an error somewhere in your experiment.*

### ***Discourse Analysis of Extract 1: Teacher’s Talk Companion Meanings about NOS, NOT and NOL***

It follows the analysis from a teacher-researcher of the companion meanings about NOS, NOT and NOL on his own talk of the extract 1:

#### **❖ *Companion meanings about NOS***

The students give only numbers without being able to prove logically their conclusions [e.g. *Student: We have found that the sandpaper is...*]. The evaluation of the process is realized in the form of closed questions posed by the teacher. With my words I demand specific answers with specific ways of inquiry, specific answers and specific ways for driving students in the “correct” conclusion, creating one-dimensional views about NOS. [e.g. *Teacher: What should you have? ...*].

❖ *Companion meanings about NOT*

I pose closed questions which aim to help students to rethink their results and their conclusions. The answers are obvious, therefore I enact a learning procedure of indirect knowledge distribution [e.g. *Teacher: What should you have?... / Didn't the surface change? /less or more...*].

❖ *Companion Meanings about NOL*

With my words I guide students very strictly to create the meaning of the language as a system of transmitting information. The students must reply with a specific linguistic code or perhaps with specific words [e.g. *Teacher: What should you have?:...less or more*]. I give to students only two choices, so the representative student of the team gives immediately an answer without being able to justify it. [e.g. *Teacher: What should you have? / Didn't the surface change? / less or more*]. I pose closed questions and I receive monosyllabic students' answers (*characteristics of a closed and monologic teacher*). It dominates the triadic dialogue pattern in a very closed and oppressive way.

Generally the analysis in the initial phase of the research indicated that the companion meanings that were created implicitly or explicitly from the teachers' talk about NOS, NOT and NOL weren't the appropriate for establishing a collaborative inquiry learning environment. For example the physical world was presented in an authoritarian perspective - as Lemke (1990) refers “not as way of talking about the world, but as the way the world is”. In the above extract the teacher was the absolute master of how classroom science should proceed, allowing students little or no participation in deciding how the curriculum would be enacted. He was closed and authoritative and functioned mainly as dispenser of knowledge (NOT), presenting to student a one-dimensional, static view about NOS and NOL. Science was therefore represented as being the domain of experts, and knowing or understanding science could be equated with knowing what answers the teacher wanted.

### **Findings - Final Phase: To a more Dialogic Discourse**

The evolution of our research indicated that the analysis by the teacher-researchers of their own discourse practices can function as a meta-didactical transformative tool. The discourse analysis mediating tools contributed in the expansive enhancement of the quality of social interactions in their science classrooms. Teachers gradually got used to be more dialogical and less authoritative. Teachers gradually appropriated and implemented strategies that supported children meanings making. The companion meanings that were created implicitly or explicitly from the dialogues that took place for the NOS, NOT and NOL were more appropriate for the establishment of more desirable collaborative inquiry conditions.

The analysis, which follows, is of a teacher-students dialogue from the final phase of the program. The extract, which precedes of the analysis, is from a science lesson naming “The roots of plans”, in a 6<sup>th</sup> grade classroom. The specific extract concerns the groups' work statements of

an activity about the classification of different kinds of buds. Teacher guides the process in the context of the whole classroom.

Extract 2: March, 2004 (6<sup>th</sup> grade, “classifying plants with different buds”)

*Teacher: Classify these plants in the table below, you will read carefully what the table demands, discuss among yourselves and then write your ideas down ... if someone has questions, discuss them. Do not write down immediately someone’s ideas. ... Let’s hear what you have decided and have written down in your group. Let’s start. Apostoli, what does your group say?*

*Apostolis (as group representative): Fibrous bud category. We put in this category the almond tree and the rosebush.*

*Teacher: The members of this group have placed almond tree and rosebush in fibrous bud category. What about the other groups? Do you agree or not?*

*All groups: Yes.*

*Teacher: Is there any group that disagrees?*

*All groups: No.*

*Teacher: Indeed, Almond tree and rosebush have fibrous buds. They have bulky and fibrous buds. Ok? We proceed in the category of vacuous bud. Let’s this group tell us. Danai tell us.*

*Danai (as group representative): Stubble.*

*Teacher: Stubble. We all agree. Do the other groups agree? Take your turn. (giving the chance to talk to the representative of another team).*

*Marilea (as group representative): We agree but we have added in this category and something else. It is the wheat.*

*Teacher: Of course, wheat. Wheat has vacuous bud too. Ok? Well, it is wheat and stubble as well. Let’ go to the next. Let’s hear the next group. Sara.*

*Sara: (as group representative): Category of soft bud. We put in this category the marguerite and the poppy...*

### ***Discourse Analysis of Extract 2: Teacher’s Talk Companion Meanings about NOS, NOT and NOL***

The analysis from a teacher-researcher of the companion meanings about NOS, NOT and NOL on his own talk of the extract 2:

#### ***❖ Companion meanings about NOS***

I try to be open in the answer of the team representatives indicating meanings of an interpretative mode for making sense of experience and physical world [e.g. *Teacher: Is there any group that disagrees?...*]. I avoid with my words to create meanings as a representative of an infallible authority. The message about science in this case is that the process of learning can involve approaching concepts indirectly, starting from everyday knowledge, with the teacher being a facilitator of the learning process rather than a source of information.

#### ***❖ Companion meanings about NOT***

My statements lead in the emergence of meanings relative with a collaborative inquiry environment [e.g. *Teacher: Classify these plants in the table below, you will read carefully what the table demands, discuss among yourselves and then write your ideas down*]. I (teacher) and my students work collaboratively to materialize the activity of classification. Students are involved in the procedure not only as individuals but also as team members. I don’t hurry to confirm a team’s view, but I seek the support or rejection from the other teams (e.g. *Teacher: Stubble. We all agree. Do the other groups agree? There you are*). I use first plural that indicates respect and confidence in all the opinions. The whole class instead of

teacher alone assesses all the opinions and proposals (e.g. *Teacher: We discuss about the classification*). Generally, I believe that I function as a facilitator of learning and I am trying to be open and dialogic.

❖ *Companion meanings about NOL*

The use of first plural indicates non-monological companion meanings about the role of the language (e.g. *Teacher: We discuss...We all agree...We put in...*). My communicative actions can be characterized as open to challenge and controversy [e.g. *Teacher: Stubble. We all agree. Do other groups agree?*]. In that way as Lotman suggests the teacher discourse could function as “devices of thinking” or as “a dynamotor of meanings”. I am trying my communicative actions to be oriented towards the support of a collaborative mode of inquiry and to help in the representation of all the student voices [e.g. *The members of this group have placed almond tree and rosebush in fibrous bud category. What about the other groups? Do you agree or not?*]

We can see from the above analysis that the companion meanings, which were created from the teachers’ talk, create the conditions for more collaborative inquiry activities. Gradually, three teacher-researchers appropriated a series of important discursive strategies to scaffold students learning, such as these that Lemke (1990) and Mortimer and Scott (2003) refer to (e.g. assist students to combine ideas or make relations, assist when interactions broke down, check on group progress, involve other students or teams in discussion, scaffold students’ learning, introduce and reinforce subject-specific concepts and language).

### **Conclusions and Implications**

Changing school culture and classroom practice isn’t an easy work. The discourse analysis tools provided teachers a meta-didactic awareness of the learning and teaching processes. Our study indicates that the process of transformation of a learning environment is a slow and vigorous procedure that needs teachers’ active participation in analyzing their own practice. The experience of our research program indicates that it is very important to involve teachers in the research and provide them with analytic tools to evaluate classroom activities and talk. The novelty of our effort is that we involved teacher-researchers in the very discourse analysis procedure that gradually led in teachers’ meta-didactical awareness for the companion meanings that they created and maintained about NOS, NOT and NOL in their classrooms during the science lessons.

In our opinion teachers can’t be familiarized with pedagogical strategies only by training, they need to be involved in the very practice and research in order to improve the ways they teach. Wertsch (1991, p. 126) supports that “*Mediational means* (like discursive cultural repertoires of teachers) *are used with little or no conscious reflection. Indeed, it is often only when confronted with a comparative example that one becomes aware of an imaginable alternative. This conscious awareness is one of the most powerful tools available for recognizing and changing forms that have unintended and often untoward consequences*”.

Discursive practices are the most important practices in a community, because they produce and mediate communication, embed all other practices, and constitute the members’ world (Roth, 1998). The discourse analysis tools provided teachers with a meta-discursive and meta-collaborative awareness. Teachers and students gradually internalized/appropriated aspects of the discourse tools that led to an automatization (Hutchins, 1997) of the dialogic and the collaborative skills.

## References

- Akerson, V. L., Abd-El-Khalick, F. & Lederman, N. G.: 2000, 'The influence of a reflective activity based approach on elementary teachers' conceptions of the nature of science', *Journal of Research in Science Teaching* 37(4), 295-317.
- Bartholomew, Osborne, & Ratcliffe: 2004, Teaching Students' "Ideas-About-Science": Five Dimensions of Effective Practice, *Science Education*, 1-28.
- Brickhouse, N. W. (1990). Teachers' beliefs about the nature of science and their relationship to classroom practice, *Journal of Teacher Education*, 41, 3 53-62.
- Bruner, J.: 1996, *The culture of education*, Cambridge, Massachusetts, London, England: Harvard University Press.
- Driver, R., Leach, J., Millar, R., & Scott, P.: 1996, *Young people's images of science*, Buckingham, England: Open University Press.
- Engeström, Y.: 1999, Activity theory and individual and social transformation (p. 19-38). In Engeström, Y., Miettinen, R., & Punamäki, R-L. (Eds.): *Perspectives on activity theory*, Cambridge: Cambridge University Press.
- Fensham, P. J.: 2002, Time to change drivers for scientific literacy. *Canadian Journal of Science, Mathematics & Technology Education*, 2(1), 9-24.
- Gee, P., & Green, J.: 1998, Discourse analysis, learning, and social practice: A methodological study, *Review of Research in Education*, 23, pp. 119-169.
- Gee, P., 1999: *An Introduction to Discourse Analysis: Theory and Method*, London, Routledge.
- Gutierrez, C., Rymes, B., & Larson, J.: 1995, James Brown vs Brown vs Board of Education: Script, counterscript, and underlife in the classroom, *Harvard Educational Review*, 65, 445-471.
- Gutierrez, K., & Rogoff, B.: 2004, Cultural ways of learning: Individual traits or repertoires of practice, *Educational Researcher*.
- Hicks, D.: 1996, Contextual inquiries: a discourse-oriented study of classroom learning. In D. Hicks (ed.): *Discourse, Learning, and Schooling*, Cambridge: Cambridge University Press, 104-141.
- Hurd, P.: 1997, *Inventing science education for the new Millennium*, New York: Teachers College Press.
- Hutchins, E.: 1997, Mediation and automatization. In Cole, Engestrom & Vasquez (Eds.), *Mind, culture, and activity: Seminal papers from the Laboratory of Comparative Human Cognition*, Cambridge: Cambridge University Press, 338-353.
- Leach, J. and Scott, P.: 2003, Individual and sociocultural views of learning in science education, *Science and Education*, 12(1), 91-113.
- Leach, J., Millar, R., Ryder, J. & Séré, M-G.: 2000, 'Epistemological understanding in science learning: the consistency of representations across contexts', *Learning and Instruction*, 10 (6), 497-527.
- Lederman, N. G., Wade, P. D. & Bell, R. L.: 1998, 'Assessing understanding of the nature of science: A historical perspective'. In McComas, W. (Ed.), *The nature of science in science education: Rationales and strategies*, Kluwer Academic Publishers, pp. 331-350.
- Lederman, N. G.: 1992, Students' and teachers' conceptions of the nature of science: A review of the research, *Journal of Research in Science Teaching*, 29 (4), 331-359.

- Lederman, N. G.: 2007, Nature of science: Past, present, and future. In Abell, S. & Lederman, N. (Eds.): *Handbook of Research on Science Education*, Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.
- Lemke, J. L.: 1990, *Talking Science: Language, Learning and Values*, Norwood, NJ: Ablex Publishing Company.
- Lemke, J.: 1995, *Textual politics: Discourse and social dynamics*, Bristol, PA: Taylor & Francis.
- Lemke, J.: 2001, Articulating Communities: Sociocultural Perspectives on Science Education, *Journal of Research on Science Teaching*, 38(3): 296-316.
- Matthews, M. R.: 1998, The Nature of Science and Science Teaching. In B.J. Fraser & K.G. Tobin (Eds.): *International Handbook of Science Education*, pp. 981-999. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- McComas, W. F., Clough, M. P. & Almazroa, H.: 1998, The Role And Character of The Nature of Science in Science Education. En W.F. McComas (Ed.), *The Nature Of Science In Science Education. Rationales and Strategies*, pp. 3-39, Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Mortimer, E., & Scott, P.: 2003, *Meaning making in secondary science classrooms*, Maidenhead-Philadelphia: Open University Press.
- Ostman, L.: 1998, How companion meanings are expressed by science Education Discourse. In Roberts, D. A., & Ostman, L. (eds): *Problems of meaning in science curriculum*, Teachers College, Columbia University: Teachers College Press.
- Roberts, D. A., & Ostman, L.: 1998, *Problems of meaning in science curriculum*. Teachers College, Columbia University: Teachers College Press.
- Rogoff B.: 2003, *The cultural nature of human development*, University Press: Oxford.
- Roth, W.-M.: 1998, *Designing communities*, Dordrecht: Kluwer Academic Publishers.
- Ryan, A.G. & Aikenhead, G.S.: 1992, 'Students' preconceptions about the epistemology of science', *Science Education* 76, 559-580.
- Scott, P.: 1998, Teacher talk and meaning making in science classrooms: A Vygotskian analysis and review, *Studies in Science education*, 32, 45-80.
- Sutton, C. R.: 1998, New perspectives on language in science. In Fraser, B. & Tobin, K. (Eds). *International Handbook of Science Education*, Dordrecht, Netherlands: Kluwer.
- Taylor, C. A.: 1994, Science as cultural practice: a rhetorical perspective, *Technical Communication Quarterly*, 3, 67-81.
- Wells, G. & Claxton, G. (Eds.): 2002, *Learning for life in the 21st century: Sociocultural perspectives on the future of education*, London: Blackwells.
- Wells, G.: 1999, *Dialogic Inquiry. Toward a Sociocultural Practice and Theory in Education*, Cambridge University Press.
- Wertsch, J., & Toma, C.: 1995, Discourse and learning in the classroom: A sociocultural approach. In L. Steffe & J. Gale (Eds.): *Constructivism in Education* (pp. 159-174), Mahwah, NJ: LEA.
- Wertsch, J.: 1991, *Voices on the Mind: A Socio-Cultural Approach to Mediated Action*, Cambridge: Cambridge University Press.
- Yerrick, R. and W.-M. Roth: 2005, *Establishing Scientific Discourse Communities: Multiple voices of teaching and research*, Lawrence Erlbaum Publishers.