

# TEACHER COMPETENCIES AND TRAINING FOR SCIENCE EDUCATION IN THE EARLY YEARS OF ELEMENTARY SCHOOL

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## TEACHER COMPETENCIES AND TRAINING FOR SCIENCE EDUCATION IN THE EARLY YEARS OF ELEMENTARY SCHOOL

**ABSTRACT:** The purpose of this paper is to analyze the ongoing training, practice and reflections of a group of teachers from a municipal elementary school in the City of São Paulo focusing an innovative project aimed at observing what factors are essential to their work in science teaching. We used three types of data: oral interactions in the course of in-service training; interviews; and analysis of classes. We noted that the teachers' participation in activities in the role of apprentices, followed by reflections and space for exchanges, was fundamental to their science teaching practice, rarely dealt with in the early school years. We concluded that articulation of the various competencies is a key factor in this science-teaching endeavor and that such competencies range from the teaching plan right through to the social relations established within the school environment.

**Keywords:** Teacher Competencies. Inquiry-Based Teaching. Ongoing/Continued Training.

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## TEACHER COMPETENCIES IN CONTINUED TRAINING

This paper describes research carried out based on a partnership between a School of Education and a Municipal Elementary School (EMEF) both in the City of São Paulo. The research featured an innovation project aimed at science education involving the ongoing training of elementary level teachers (Ensino Fundamental I).

The basic proposal for this training featured work with teaching sequences that included the object of promoting the students' scientific literacy as well as working theoretic fundamentals and current research featuring the classroom and Science teaching. The above-mentioned EMEF already had a history of innovative work analyzed by other researchers (AZEVEDO; ABIB, 2009) that highlighted collaborative work between teachers and coordinators, in addition to the development of a Science laboratory by the group itself aimed at inserting science into everyday school work. In spite of these elements the group felt a lack of methodological-theoretic support and of specific training in the area for systematic work with science teaching which led the group members to seek a partnership with the university.

The implementation of a partnership project in the school was achieved thanks to CNPQ funding in 2008 and as of that time, the analysis of classroom data (filming, and students' textual productions) began to show good results as compared to development of the students' scientific literacy, in addition to changes in the practices of some teachers (AFONSO; SASSERON; CARVALHO, 2009).

Based on this scenario, on three occasions – during the training held with the group of teachers, in their life history, and in the in-service actions of one of the teachers taking part in the group – we noted the competencies being developed or already in action that we judged important and definitive for the implementation of innovation involving science. We used the concept of competency as a basis to assess the development and needs necessary to the training in view of an insertion of generalist teachers (those who work with various subjects of elementary teaching and not merely Science) in a more specific universe, because this insertion is not direct.

It is well known that in the first years of elementary education, classes in most subjects are given by generalist teachers and that, in general, the practice covers various fields of knowledge, science being merely one of the subjects included in a diversified curriculum.

Several works (LIMA; MAUÉS, 2006; BRICCIA et. al., 2008) have pointed out that science is not often addressed in the early years of elementary school. Authors that deal with the topic point to some variables that explain this fact. We noted that in addition to having lacked good science courses during their basic teaching courses, the teachers also lacked more extensive contact with this field of knowledge during their initial in-service training. Gualberto and Almeida (2009), in an analysis of some initial teacher training courses (education), point out that only 2-3% of the total course load is dedicated to specific teaching methodologies (math or science, for example), and that often involving only theory without addressing relations among different fields of knowledge.

Another factor noted was that more is demanded of teachers in relation to certain subjects, such as Portuguese language and math (LIMA; MAUÉS, 2007; BRICCIA et. al., 2008). This being the case, teachers tend to dismiss work with science content because they feel that they are more strictly evaluated in relation to language, literacy, and mathematics.

Brandi and Gurgel (2002) point out that the National Science Standard (PCN) specifies that the relation of science with other fields of knowledge should be in place as of the initial years, including collaborating toward the development of reading and writing processes, characteristics also pointed out by Lopes and Dulac (2007), and Liu and Akerson (2002). Liu and Akerson (2002) also emphasize that effective science learning requires more than an approach to texts that present facts, or the handling of “cute” things, very often common in the early years.

Brandi and Gurgel also point out that:

Despite its acknowledged importance, science teaching has failed to achieve the success necessary in this process because although teachers of the lower grades of elementary school in Brazil receive multi-discipline training, they are not really qualified to introduce students to that form of teaching. In fact, on the contrary, in most cases teaching features the exclusive use of textbooks. It is quite common for teachers to work with the reading of texts that offer ready-made answers that correspond directly to the questions on questionnaires that follow the texts. This practice leads to science classes in school being given more regularly only after the students have learned to read and write. (p. 114)

It is thus our understanding that mere initial training and the scant insertion of science up to the present have been insufficient to arouse teachers' interest in knowledge dealing with new methodologies, knowledge of subject content, epistemological discussions regarding scientific knowledge, and other knowledge specific to the area, all of which highlights the need for continued training.

In view of this context, a fundamental question in relation to teacher training and the implementation of a proposal that involves work with science education is: What aspects and competencies are essential to training that encourages meaningful introduction of generalist teachers in this field of knowledge?

The purpose of this paper is therefore to investigate that question based on the analysis of a training process that led to a teaching practice considered successful. This was achieved by filming classes and training meetings where we sought to comprehend what relations occur within the school environment to favor the success of an innovative project, and to analyze how the classroom actions related to training.

Analyzing such questions also became important for us to understand how the relation between continued training and in-service practice takes place since we are aware that a good deal of the training carried out fails to be implemented within the school environments.

The research presented herein allowed us to observe that a successful job does not have to do exclusively with training, but also with all of the movement existing in the school in regard to a project's receptivity and support, as well as the

teachers' own characteristics and interests in relation to their concern with their own training, among other aspects that we will discuss further on.

Our research began with initial observations of the school environment and the interactions in ongoing training activities with the group of teachers. In the course of those observations we approached the referential of teacher competencies, initially based on the works of Philip Perrenoud, since that referential, apart from the necessary knowledges, was related to the human relations existing within the school environment, the classroom work, and other aspects that were found in our preliminary observations. We believe that the idea of competencies gave us a larger dimension than what we had intended to observe.

We are well aware that there are differences of opinion and controversies regarding the idea of competencies, that the idea is not new in education (DIAS; LOPES, 2003), and that in other decades it was central to teacher training. However, apart from the observation of our data indicating that sources regarding competencies would be the most suitable to our analysis, we also found rationalizations by authors that this idea is being more and more frequently presented as fundamental in defining the needs of teaching practices in official reform documents of various countries (PANTIĆ; WUBBELS, 2009), as well as being central to references for teacher training in Brazil (DIAS; LOPES, 2003).

## TEACHER COMPETENCIES: A THEORETIC OVERVIEW

The quest for authors that focus the idea of competency in the realm of the teaching profession led to the discovery of theoretic works on the topic such as those of Perrenoud (2000), Cano (2005), Koster et. Al. (2005), Garcia et. Al. (2008), as well as practical research involving the observation and assessment of teacher competencies presented by authors who study the teacher training process, among them the works of Glaser-Zikuda, M. and Fub, S. (2008), Oliva et. al. (2009), Pozo and Oliva (2009), among others.

Those authors conceive the idea of competency as the capacity to articulate and mobilize knowledge, attitudes, ways of thinking, and capabilities in diverse situations, to that end involving personal relations that occur within the school environment, support of the school environment, the teachers' life histories and how they relate to their professionalization (PERRENOUD, 2000; CANO, 2005; GÁRCIA, 2008).

We noted that in all the references presented above, the relation between these diverse factors, or categories as some authors prefer to call them, indicate the teacher's job as a complex one involving aspects that demand not only theoretic and practical knowledge about their work, but also the combination of various aspects.

Phillippe Perrenoud (2000) highlights a relation between competency and action. To that author, having knowledge or capabilities does not mean being competent since competency goes beyond knowledge and must be linked to being capable of carrying out certain actions. The author points out that a teacher may have knowledge of theories related to teaching, know how to act in certain

situations, but not manage to act appropriately when facing complex situations that occur on a daily basis or, as presented by Sanmarti (2005), not know how to act with initiative and autonomy in such situations.

Referring to action, Perrenoud (2000, p. 15) also points out that

the exercise of competency involves complex mental operations, taken for granted by thought patterns that allow one to determine (more or less consistently and quickly) and carry out (in a more or less effective manner) an action relatively well adapted to the situation.

We can understand that this constitutes a relation of complexity with knowledge because we cannot separate knowledge from the combination, from the action, from the relation with other knowledges, or even from the social aspects of the school environment. This idea of complexity is based on the principles pointed out by Edgar Morin (2005) where complex thinking means disaffirming certain classic scientific principles such as order, dissociability, and reason. The idea of separability, that which best fits our case, comprehends the principle that phenomena can classically be studied separately without any interaction taking place among them. It is our understanding that classroom study breaks away from this idea because to study such a phenomenon we cannot break it down into simple elements, and this contradicts the idea of complex thinking.

Some authors who analyze science teaching also acknowledge this complexity as being related to the exercise of teaching. Although the authors that we will cite below do not explicitly present the idea of competency, it is our understanding that such ideas present principles that imply competency. Hodson & Hodson (1999), for example, point out that within the complex system that the classroom represents the teacher is faced with variables and questions and must know how to organize both the nature and the time for interventions and actions. Seen that not only knowledge is important, but also how to intervene, we can infer that two different teachers, faced with an identical teaching orientation, may act in totally different ways, arriving at positive results or not, depending on how they inter-relate their various fields of knowledge and mobilize their diverse competencies.

Perrenoud (2000) highlights that the mobilization of resources is only pertinent in certain situations and that each situation relates to one certain context in a unique manner even though one's way of dealing with it may be analogous with others encountered previously. Although to this author, the capacity for such mobilizations, like the competencies, are constructed during training, be it initial or continued, and to the taste of a teacher's daily navigation from one work situation to another (Perrenoud, op, cit.).

Based on these and other analyses of the concept of competency, be it related to the general work characteristics of teaching or merely to practices in science education, among the authors consulted we found regularities or aspects in common. Although some authors of the field of science teaching do not use the term competencies, they do feature certain characteristics of the job of teaching, such as the type of questions they ask and the environment they create in their

classes (MACHADO; SASSERON, 2007), skills necessary to encourage scientific enculturation (CARVALHO, 2007), that are similar to the ideas of competencies presented by Perrenoud and others. Therefore, we will use these works also as reference.

In the chart below we also present elements of a document of the State of Florida (USA) from the year 2007 that states explicitly the “Competencies for Teachers of the 21st Century”. Our choice of the analysis of this document came about due to that explicit relation to the concept of teacher competencies which is not presented explicitly in Brazilian documents such as the PCN, for example.

Throughout the whole of this analysis we compiled the categories of competencies explicit in Chart 1 below.

Chart 1

	COMPETENCIES	INDICATORS OF THOSE COMPETENCIES
Planning	Organize/Plan learning situations	Knowing the contents to be taught and their translation into learning objectives ((FLORIDA, 1998; PERRENOUD, 2000). Planning activities so that students develop scientific competencies: order data, solve problems, register. (GIL PÉREZ et al., 2005).
Directing the Teaching-Learning Process	Direct learning situations	Work based on hypotheses, errors, and students’ learning obstacles; promote integration with other fields of knowledge. Reflect on the interest of situations presented in the classroom. (PERRENOUD, 2000; GIL PÉREZ, et al., 2005; FLORIDA, 1998 GARCÍA, 2008;; CARVALHO, 2007). Propose problems, questions, and dilemmas in class. Promote opportunities for students to develop scientific competencies, raise hypotheses, explain, etc. (HODSON; HODSON, 1998; CARVALHO et al., 1998; GIL PÉREZ et al., 2005; MACHADO; SASSERON, 2012).
	Create a learning environment that involves students in your work	Establish positive interactions within the learning environment using incentives and ensuring that interests and opinions count. Organize work teams. Share responsibilities for the learning environment with the students. (FLORIDA, 1998; GIL PÉREZ, et al., 2005; FRASER, 2007; PERRENOUD, 2000).
	Mediate ethical relations and questions	Accept and value students of diverse cultures, languages, and levels of learning and treat them equally promoting an environment where all are treated equally, thus protecting the students from harmful conditions (FLORIDA, 1998; GIL PÉREZ, et al., 2005).

<b>Process Assessment</b>	<b>Conceive and develop means for differentiating and assessing</b>	<b>Administer the heterogeneity in team environments (FLORIDA, 1998; PERRENOUD, 2000). Give integrated support, working with students who have major difficulties (PERRENOUD, 2000). Encourage students to compare their conceptual and methodological evolution by means of feedback (GIL PÉREZ et al., 2005; GARCÍA, 2008). Promote the construction of work syntheses (CARVALHO et al., 1998; GIL PÉREZ et al., 2005). Pay attention to communication as an aspect of scientific activity and as essential to assessment (GIL PÉREZ et al., 2005).</b>
	<b>Work based on longitudinal teaching objectives</b>	<b>Together with other teachers, analyze students' results, references and evidence of progress to inform the teaching processes (PERRENOUD, 2000). Plan and implement activities connecting theory, goals, learning activities, results and assessment with a view to achieving long term objectives. (FLORIDA, 1998; PERRENOUD, 2000).</b>
	<b>Develop team work (Collaborative work)</b>	<b>Draw up and direct a team project, common representations (PERRENOUD, 2000; CANO, 2005). Face or analyze a set of complex professional situations, practices and problems such as classroom observations as a team (FLORIDA, 2008; PERRENOUD, 2000). Take part in the development of plans for improvement that support the school's development plan, also involving the school community (PERRENOUD, 2000).</b>
	<b>Seek your ongoing/continued development</b>	<b>Know how to state your own training practices and needs explicitly (PERRENOUD, 2000). Use data from your learning environment to assess the teaching-learning processes in collaboration with the team (FLORIDA, 1998; PERRENOUD, 2000). Get involved in teaching order or educational system scale tasks aimed at training (PERRENOUD, 2000). Negotiate a training and common life experience project with colleagues (team, school, network) (PERRENOUD, 2000).</b>

Chart 1: Competencies related to school work according to various authors.

We observed competencies involved in three distinct instances: planning, conducting the teaching-learning process, and assessment of the teaching-learning process. This last instance is related to teachers' self-assessment of their practice.

The theoretic aspects related to competency, specified above, and the observation of those competencies in action, led us to investigate the teaching competencies at different moments in the environment of continued training and in the school environment in order to understand what factors are important upon the implementation of an innovative proposal for science.



## DESCRIBING OUR ANALYSIS

The research presented herein is of the case-study qualitative type because, according to Ludke and André (1986), this type of research features a descriptive nature and the direct source of data is a natural environment – training and practice. The focal points were broad in the beginning – aspects of the training – and became more direct and specific during development of the study.

In a more recent article, André (2013) highlights that in view of what various authors discuss regarding use of a case study in education, one finds two traits in common:

- a) the case must have a particularity that is worthy of investigation; and b) the study must consider the multiplicity of aspects that characterize the case. This will require the use of multiple methodological procedures to develop an in-depth study. (p. 98).

It is also characterized as a case study because it presents characteristics pointed out by Yin (2010) who states that a case study is an empiric investigation that investigates a contemporary phenomenon in depth and in its real life context (p. 39), since we investigate in depth the relation and competencies that exist during teacher training. It is also characterized as a representative or typical case study the object of which is to capture the circumstances of a situation, and which, still according to Yin (2010, p. 72), can be characterized by a representative school, as in our case.

To this end, we had a single research context since the data analyzed were obtained in the above-mentioned partnership project established between the EMEF (public elementary school) and the School of Education (USP). This project featured an innovative partnership action as well as a quest for improvement in classroom work, making making up the unique characteristics of this training environment.

The partnership featured monthly training meetings based on which, and on the practices and reflections resulting from them, we used three types of data. The data was gleaned from transcriptions of the filming of: (1) meetings between the EMEF and the university training team; (2) the application of a teaching sequence [Navegação e Meio Ambiente, SASSERON; CARVALHO (2008)] by one of the teachers; and (3) a semi-structured interview with that same teacher.

We sought to focus our analysis on only one teacher, Nora, who carried out the interview and had her classes filmed. However, in the course of the training classes, we noticed interaction among the members of the group of teachers – once there were dialogues among them – and eliminating only the utterance of that one teacher would render the whole context senseless.

The teacher analyzed had a background of 20 years of training and experience in teaching with initial college specialization in the Portuguese language, as well as various courses in related areas. During her interview she pointed out that in the course of those 20 years she had not worked systematically with sciences because it was not required of her and also because science was not her specialty. Therefore, despite her long years of experience she was entering a



new field of work, a fact that reinforces the positions presented in the beginning of this paper regarding teachers' lack of involvement with the teaching of science in the early years of elementary school.

Based on each one of the transcriptions, we sought evidence of the existence of each one of the categories of competencies we compiled of the theory shown in Chart 1. It should be pointed out that the research project was evaluated by the ethics committee of the School of Education and that all names presented are fictitious and the identity of all participants was safeguarded.

## TEACHER TRAINING NEEDS

In the introduction of this paper we proposed to discuss the following question: What aspects and competencies are essential to training that encourages meaningful introduction of generalist teachers in this field of knowledge?

The discussion of this question took place based on the concept of teacher competencies which, as mentioned previously, we believe to include the various aspects contained in teacher training and in teachers' daily work. We thus observed the evidence of these competencies based on their characteristics during the diverse moments analyzed. It is important to show that the complete research work (BRICCIA, 2012) was based on the analysis of 42 episodes – one of each training moment (meetings). In this article we will present some aspects of our analysis based on the categories of competencies mentioned and on the moments we characterized as teaching moments, divided among Training and Planning, Conducting the Teaching-Learning Process, and Process Assessment.

## TRAINING AND PLANNING FOR TEACHING

Initially we presented the aspects that refer to in-service training and favoring contact and the work of generalist teachers with the field of knowledge. In the beginning we noted that the teachers who took part in the project are, above all, seeking their own on-going development. They get involved with school projects and with the work team (group of teachers and coordinators) based on a need for improvement. This fact is a characteristic of this group and is also one of the types of competency presented as fundamental to everyday work in schools.

The group from the School of Education enters a scenario in which a large portion of the teachers already has years of teaching experience, but has not worked with science. The strategy used to involve the teachers in this scenario featured working with them as apprentices, taking part in work that involved methodologies as well as science contents allowing them to build up their confidence to work these subjects with their students.

In one of the training meetings, the teachers solved a problem involving a knowledge of physics, or the problem of the little boat<sup>1</sup> (CARVALHO et. al., 1998), the object of which was to work with the concepts of distribution and

density, as well as aspects of inquiry-based teaching and, soon thereafter, only with the coordination, the teachers watched a video<sup>2</sup> of the same activity filmed previously by the university, on that occasion carried out with the students who discussed the concepts and methodologies involved. Following these moments, some teachers carried out inquiry-based activities in their classrooms and brought their impressions to the second meeting with the group of trainers from the School of Education. The episode below portrays the dialogue among some teachers and the trainer, and the questions that arose in relation to application and assessment of the activity.

Chart 2

TRACK	SUBJECT	UTTERANCES
27	Marina	When watching the film we were with some level 2 teachers, one of math and one of history and, in the film, it is quite clear that the teacher gives a command and disappears. The teacher does not interfere at all, so much so that although they try again and again, they get no interference from the teacher. At that moment, is it really only a question of commanding?
28	Trainer 2	You recall what we advise you to do: make the problem clear to them – and in this case the problem is to use the paper they were given to build a little boat that, when placed in the water, manages to carry the greatest number of pieces without sinking. That is the problem. The teacher, ... walks around among the groups making sure they all understood the problem, but without giving any tips as to how the boat should be made...
...		
31	Nora	We noticed that one class took a long time.
...		
38	Marina	Right, because in the film it wasn't made clear. The teacher gives the command, I don't know if everyone realized that at the time when we watched the film. The teacher gives the command and that's it. Then, just because I'm very anxious I want to say "come on, get a move on"...
39	Trainer 2	No, the teacher does that but it's that the film is...
40	Marina	Ah! Because we said: and now, what is the teacher's stance?

Chart 2: Excerpt of one of the meetings, showing the construction of knowledge being carried out during training.

This excerpt focuses more on Marina's utterances, but in this and in other moments we see that other teachers, such as Nora, present questions regarding the training for application of the activities. In Chart 2, we see that in tracks 27,

38 and 40, by means of questions such as “what is the teacher’s stance?”, “at that moment, is it really only a question of giving a command?”, the teacher points out her doubts as to work methodology, that is, the proposal of inquiry-based teaching.

We noted that the teachers showed indications of being accustomed to conducting activities and begin to question the time students take (“took a long time”) and their own time which in this proposal is different from a conventional proposal. Upon airing these questions and doubts, the teachers also seek means of dealing with their anxiety (also described at other times) in relation to the work in the classroom or to the time needed for the students to construct the knowledge without interference on the part of the teacher.

During these reflections and questionings, knowledge is being constructed – in this case, methodological – as well as a work plan for their actions in the classroom which, according to some authors (FLORIDA, 1998; PERRENOUD, 2000), characterize the construction of competencies in the sense of Organize/Plan learning situations, since these involve both the construction of methodological knowledge and planning of classroom work.

To those authors, some of the indicators of this category are: to know – for some certain subject – the content to be taught and its translation into learning goals (FLORIDA, 1998; PERRENOUD, 2000; GÁRCIA, 2008); to plan activities so that students develop scientific competencies (FLORIDA, 1998).

Thus, we noted that those two characteristics are present in this construction since, despite having general knowledge about education, the methodology involved and the specific objectives of the subject are still undergoing construction.

When focusing the interview with Nora more specifically, we also found aspects of this construction and of the work in practice, as is shown in the following excerpt:

**Chart 3**

TRACK	SUBJECT	TRANSCRIBED UTTERANCE
126	Nora	I'll tell you what changed – the field of science changed! Because this, this question of working with what children already know, to start from their reality, to discover the extent of their previous knowledge, that I already did – very well – in Portuguese, math, or history. I had this obsession. Science seemed to me like I had to follow the book because I wasn't very confident in that area, you know? Now you might say that I'm more daring...
127	Interviewer	Calmer.

128	Nora	<b>Now I manage to use the science book better. For example, if I'm going to start with the human body, I'm not going to start like it is here in the book... there, I think I learned from this study, always start by questioning. Here I can say that I always called the coordinator, or sent an e-mail: "I thought about maybe starting the content with this question... what do you think?" So now I do this more in science class... starting with a challenge, a question, and then going on into the content.</b>
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Chart 3: Excerpt of the interview showing the teacher's construction of knowledge.

The stretch described in Chart 3, as well as other moments of the interview, demonstrate the construction of methodological and conceptual content on the part of the teacher. On track 128, for example, the teacher points to the fact of always beginning with a question. That rule is one of the pillars of inquiry-based teaching until then unknown to her. In other moments of the interview, the teacher tells about having tried to create new teaching sequences for science teaching, presenting the difficulties, the positive and negative aspects she found. Even without analyzing those difficulties, we see that there is construction in this process, we see involvement of the teacher who, despite long years of teaching experience had not worked science contents, and the demonstration of a new way of working with science based on didactic-pedagogic presumptions regarding teaching of the subject.

It is thus our belief that within teachers' quest for personal development, they must construct both conceptual and methodological knowledge about science teaching because they are dealing with a universe still unknown to them and although knowing the specific content of the subject is an essential condition for teachers it is not sufficient for their job (CARVALHO, 2007). There are skills and knowledge regarding how to work the subject that must be experienced by teachers in training.

We see that the continued training developed was strongly linked to the specific knowledge of teaching and also to the planning of activities for the job of teaching.

## DIRECTING THE TEACHING-LEARNING PROCESS

Pedagogic knowledge is also related to ways of working in the classroom. We are aware that generalist teachers, as stated by authors (LIMA; MAUÉS, 2006), may have this type of knowledge, but that is not sufficient for them to have knowledge regarding work methodologies specific to science teaching. We thus believe that such aspects must be worked with the specificities required for the field of knowledge since actions in the classroom span general teaching objectives as well as objectives specific to science learning. Therefore, we point out the competencies related to Directing learning situations involved in science teaching as shown in Chart 1.

In addition to those competencies, we noted that various researches in the field of scientific education (Chart 1) point to the Creation of an environment that involves students in the teachers' work, relating how teachers establish positive interactions among the students with the creation of an environment where it is possible to voice and exchange ideas, fundamental to the development of objectives that bear in mind scientific literacy and/or argumentation on the part of students. These aspects are linked to the social construction of knowledge, as well as to attitudes to be developed in the classroom and are pointed out in the PCNs (BRASIL, 1997) as essential.

The teaching episode below shows us the exercise of the teacher Nora in her classroom, soon after she had applied the activity of the little boat. In this episode some aspects are pointed out that promote the development of science learning, introducing the students to inquiry-based teaching and bringing us signs of competencies specific to Directing learning situations and to Creating a learning environment that involves students in the teachers' work.

**Chart 4**

TRACK	SUBJECT	TRANSCRIBED UTTERANCE
33	Teacher	<b>And it didn't sink... Why do you suppose it worked? Many... that I perceived during the experiment was how A3 said: You tried first that boat made of paper and it didn't work and you said that you made a square boat or a round boat and another used the term raft. Why do you think it worked when you did this? Why would that be? Hey, slowly! (lots of people talking at once)</b>
34	A17	<b>Because we worked together.</b>
35	Teacher	<b>Only because you worked together:?</b>
36	A5	<b>Because we put 5 sheets of paper together to make the raft.</b>
37	A8	<b>Then it couldn't sink because there was a lot!</b>
38	Teacher	<b>Then why didn't it sink? What was there a lot of?</b>
39	Several	<b>Paper!</b>
40	Teacher	<b>What else? Speak up A6.</b>
41	A6	<b>It's because we were loading it with a lot of aluminum, lots of washers, and distributing the weight.</b>

42	Teacher	<b>So you distributed the weight. Tell me about it A9.</b>
43	A9	<b>Ours was different. We used two sheets of paper and it didn't work. Then we used 5 sheets – too much. That didn't work either – the boat sank.</b>
44	Teacher	<b>You see how interesting this is? Five sheets of paper, while the other group used two sheets. Could the solution be merely the amount of paper?</b>
45	Several	<b>No...</b>
46	Teacher	<b>Then what is it?</b>
47	Several	<b>They're distributing the weight...</b>

Chart 4: Teaching episode that shows us signs of teacher competencies in relation to conducting work in the classroom.

Chart 4 showed that the teacher conducts her class using the inquiry-based stance when proposing questions and problems to the students (tracks 33, 35, 38, 40, 44, 46) asking them how they went about solving the problem and encouraging the construction of answers by the students themselves.

In tracks 40 and 42, the teacher encourages the students to take part at the same time as she works based on the hypotheses they raise in order to question them with the intention of getting them to organize their ideas, construct explanations for the solution they found, and to place the students' initial ideas in conflict.

Some students point out that the number of sheets of paper was important for the boat to carry more little pieces. The teacher then confronts those hypotheses and leads the whole class to discuss and construct the knowledge collectively instead of individually.

We also understand that aspects of the training are related to those questionings since the teachers work with knowledge related to work with the students in relation to inquiry-based teaching and aspects related to their scientific literacy that highlight argumentation, the construction of explanations, work with the students' hypotheses, among others, as essential for the construction of scientific knowledge. The actual objects of teacher questionings in relation to the methodology presented previously appear here, explicitly.

We thus see that in this and in other moments of the research not explained herein, the work features longitudinal teaching objectives since the activities – theory, goals, learning activities, results, and assessment – are connected with a view to long-term objectives.

## ASSESSMENT OF THE TEACHING-LEARNING PROCESS

During many moments of the interview held with Nora and presented above in Chart 3, the teacher claims to plan and to clear up any doubts regarding her classes and actions with the coordination by means of questions, e-mails, phone calls, etc. It is not our intention to analyze the nature of those exchanges but it is important to note that the new practice induces some amount of insecurity, doubts regarding its application and, that a support figure within the school environment is essential if teachers are to feel capable of taking part and carrying out an innovative proposal in their classrooms.

We also noted that involvement with other teachers in a teamwork effort also exists when applying the project because even in the absence of the group of trainers, the teachers discussed work methodologies and problems encountered in the classroom among themselves. This is also shown in the utterance below regarding a question that arose in the application of a mathematical<sup>3</sup> challenge, applied prior to the problem of the little boat.

Chart 5

TRACK	SUBJECT	TRANSCRIBED UTTERANCE
75	Coord.	<p><b>There is a noteworthy aspect of the mathematical challenge. It is that the children... very little, they want... I think it led us to think a lot about how math is taught. Why do the children only want to do arithmetic problems? It took a long time for them to answer and only one said that it's impossible; this isn't a problem of multiplication, division, addition, subtraction – the four operations – and that was enough. Then I said: look, if you weren't able to solve the problem, look at it from another angle. So the teacher goes there, gives a general tip, so then some elements were important. It was as though there were obstacles in the way of solving the challenge. One was in regard to problems, which led us to really want to talk about teaching math. It led everyone to this reflection, in all the classrooms, and even the fact that the children are not attached to this system of arithmetic problems... They have... Are they freer from decoding from writing, and from problems? Wasn't it this that led to the quest for another solution, to appeal first to the path of reasoning, wasn't it? No matter how many learning problems they may have, all these questions, are they really prisoners to the context of arithmetic problems?</b></p>

Chart 5: Description of reflection based on a question that arose in practice.

In the utterance presented in Chart 5, the coordinator explains that the teachers reflect on students' learning in relation the math teaching, facing or analyzing a complex situation related to the students' learning as a group, which characterizes a group quest for a solution to a problem – Teamwork. The problems



observed by the teachers in their classrooms were raised, generating a sign of a Quest for continued training, since both coordination and teachers use data from their learning environment to begin a “conversation” about math teaching and ways of constructing knowledge. In this and in other moments during the meetings, we see an environment propitious to the construction and exchange of ideas, generating improvement in classroom work for all. There is another important moment when, in a similar fashion, the teachers describe that the difficulties in relation to students’ writing made them think about the development of their writing and literacy. These are moments of assessment of work in the classroom and of references that characterize a reflection and a constant quest for new alternatives for the classroom as well as for Teamwork.

## CONCLUSIONS

Let’s get back to the question presented at the beginning of this paper: What aspects and competencies are essential to training that encourages meaningful introduction of generalist teachers in this field of knowledge?

Some aspects essential to teacher training and practice when dealing with insertion into a new field of knowledge were shown by means of this experiment in training and research.

The first of those aspects is in regard to the training model. Currently, there is discussion about whether working with specific contents of the area during training is sufficient for the teachers, and also if it is necessary; in other words, if the training model proposed in current Brazilian references includes this specificity (DIAS; LOPES, 2003). This research also showed that there is a need for development of knowledge specific to this field since science didactics has both the methodologic and conceptual knowledge characteristic and unique to this field that proved to be essential for the insertion of teachers into this universe. We thus defend that the training of generalist teachers, be it initial or continued, must deal with competencies fitting to specific knowledge and planning of the area, which corresponds to the category of competencies defined as Organize/Plan Learning Situations pointed out as fundamental in the works of Perrenoud, 2000; Florida, 1998; Gil Pérez et. al., 2005.

Based on the actions observed, we also defend that this training must be directly related to practice. Going through the situation of teaching in the role of apprentice, observing one’s own practice, reflecting on how activities will be applied in the classroom (the teacher’s attitude, questions that must be asked, time for the students to reflect on the activity) are fundamental steps that allow teachers to develop confidence in the development of the subject and consequently the moment of Directing the Teaching-Learning Process. We believe that training aimed more toward practice and discussion that emphasizes the learning of content as well as work methodologies favors the contact and insertion of generalist teachers in the field of knowledge. As works like those of Machado and Sasseron (2012); Fraser (2007); Carvalho (2007) point out, how teachers conduct work in the classroom is determined by the type

of discussions and interactions they induce. However, it is necessary to work on these methodological aspects with teachers, aspects that are often lacking in training, whether initial or continued.

In the classroom or at the moment of conducting the learning process, we noted that the teachers' work was based on the students' hypotheses, errors, and learning obstacles, on the proposition of questions, dilemmas and problems in the classroom, promoting argumentation among the students, characteristic and fundamental in this field of knowledge. This supports the Organization and Planning of Learning Situations, as well as their relation with Longitudinal Objectives for Teaching with characteristics specific to science education and to the insertion of students in a process of scientific literacy. Once again we refer to the works of Carvalho (2007) and Fraser (2007) stating that teachers create an environment in classrooms where interaction and the construction of knowledge are possible.

However, our data tell us that even working these constructions, other aspects are also important since we noted some lack of self confidence in the teachers in relation to their insertion in a new universe. Thus, we refer to another factor fundamental to this training: a space for reflection, feedback, and dialogue in the training as well as within the school environment, or the moment of Assessment of the Teaching-Learning Process. We understand that the process of insertion of the teachers in teaching proposals does not come about merely with some eventual work, but by means of an ongoing and cyclical process that involves learning, reflection, and feedback of results, followed by further reflection.

Another factor fundamental to insertion of the teachers is Teamwork, developed within the school environment and supporting the application of activities plus teacher-coordination involvement and support for and with the proposal. As pointed out by Perrenoud (2000), Cano (2005) and various authors who present collaborative work as fundamental, we note that the interaction among peers creates a support network essential to continuity in any innovation process. We see as well that this teamwork, among other factors, provides the quest for own training (PERRENOUD, 2000; FLORIDA, 1998) by means of the quest for texts and theoretic elements for the practice, reflecting questions or problems that arise within the work environment itself and thus creating an environment propitious to the development of an innovative proposal.

We see that a good training job or a solid continued training structure includes various areas of competencies that intertwine and speak to one another, mobilized to achieve a good action or to support a proposal within a work environment. Although we do not present all the categories of competencies in this text, in our research we found evidence of the existence of all the theoretic categories presented in Chart 1.

We again highlight that it is essential that training favor aspects related to specific knowledge of the area, that it provide development of the everyday aspects of work in the classroom, that highlight methodologies and content as well as knowledge regarding the construction of students' knowledge, but that also involves the quest for teacher training and is supported by a work team or

by the directorship of the school itself when there is any lack of confidence in work with a new area of knowledge.

The figure below shows a scheme that demonstrates characteristics of this training:

**Figure 1**

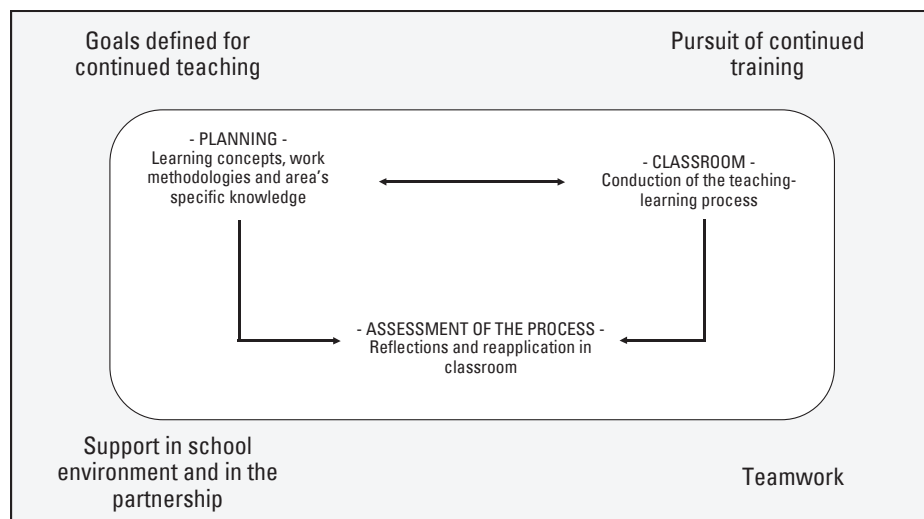


Figure 1: Training Model demonstrated in our research.

The scheme presented makes clear a training model that values the three stages of work: Planning, Conducting Work in the Classroom, and Assessment of the Teaching Process, involving the teachers' training and work. Our data thus showed us the categories of competencies highlighted in Chart 1.

We believe that this model is also valid for initial teacher training because in training, apart from the fundamentals related to the sciences, it is also necessary to construct the methodological and conceptual aspects of this knowledge and reflections on work in the classroom, and that the teachers in training already build skills and a relation with science knowledge (CARVALHO, 2007). We thus defend that reflections, proposals, and methodologies that demonstrate practices with scientific work as well as theoretic aspects be focused as of the initial training.

We also conclude that teachers' involvement with a new subject does not come about thanks to random competencies or knowledge, but by means of a series of competencies that must be present in training and in practice, and that all of these relate to one another, intertwining in a complex manner. Each one of them and the articulation of all are fundamental within the training and development process in the school environment.

## NOTES

<sup>1</sup>The boat's problem consists of the construction of a boat with an aluminum foil based on the following problem: How to build a boat that carries the most amount of pieces floating in water without sinking.

<sup>2</sup>This and other videos about physics knowledge can be found at Lapef's page: <<http://paje.fe.usp.br/estrutura/midiavirtual.htm>>.

<sup>3</sup>The math's challenge consists in the following problem: how to cross three man from one margin of the river to the other with the help of a boat that doesn't float carrying over 130kg? The men have different masses: 60, 65 and 80 kilograms.

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