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# ComPratica: A Virtual Community of Practice for Promoting Biology Teachers' Professional Development in Brazil

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**Abstract** Teachers' professional development is a key factor in improving science education, but it shows limited impact when only a small number of teachers is reached, or when it focuses on only one aspect of teachers' development, such as learning science content, and is disconnected from teachers' practice. In order to increase the impact of our work on teachers' professional development, we implemented in 2007 ComPratica, an online network intended to establish a virtual community of practice involving biology teachers and biological education researchers. We present here the results of the first 2 years of this project, obtained through an analysis of the number and distribution of actions performed by the participants in the community, the kinds of activities in which they are engaged, and the themes addressed in their messages. From these data, we conclude that ComPratica is effectively functioning as a community of practice and is leading to changes related to both teachers' and researchers' professional development, which seem capable of reducing the research–practice gap in science education.

**Keywords** Community of practice · Teachers' professional development · Research–practice gap · Online networks

## Introduction

As it is the case in many other countries, to improve science education at the primary and secondary levels is a major concern in Brazil. For instance, in the so-called *Blue book* (MCT

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2010), resulting from the 4th National Conference of Science, Technology, and Innovation, which was convened by a presidential decree to discuss the Brazilian scientific and technological policy, one of the central proposals is to establish mechanisms that can broaden the contribution of science and technology institutions and agents for the improvement of science education past primary school. A challenge, however, is to expand the very conception of these institutions and agents about what is required to build a better science education in the country. For many years, a lot of isolated training courses and seminars were offered to the teachers, mostly focused on increasing or updating their science content knowledge, but typically not dealing with many other elements involved in pedagogical practice besides content understanding. This is in stark opposition to the fact that there is a very active community of science education researchers in Brazil, who have been producing a lot of research results concerning not only science content, but several other aspects of science teaching. It also enters into conflict with the fact that many professional Masters courses for in-service teachers have been implemented in several universities during the last decade, bringing relevant contributions importantly involving content understanding, but not limited to this aspect.

A broad literature stresses teachers' professional development as one of the key—if not the most important—factor in improving science education (e.g., Harrison et al. 2008; Ostermeier et al. 2010). Initiatives in promoting teachers' professional development show limited impact, however, when they reach only a little fraction of the teachers of a country (particularly, in a country with a continental size such as Brazil). Moreover, when they are also fragmented—for instance, focusing on only one aspect of teachers' development, such as learning science content—and disconnected from teachers' practice, they are even more limited. As research in science education has shown, isolated courses about content or new didactical approaches are not enough to supply the concrete needs teachers experience in their classrooms: in order to incorporate the innovations learnt in these courses, they have to reformulate the research findings, generally alone, to meet their concrete reality, a task that can be quite difficult for the teachers (Briscoe 1991; Mellado 1998; Lüdke et al. 2001). As a result, teachers often do not see clearly the benefits of these innovations for their professional development.

In fact, recent research in education indicates that teacher learning must take place within school and classroom settings (Borko and Putnam 1996), since in order to change classroom practice, teachers must establish strong links with their beliefs and classroom contexts. Also, teachers must have plentiful time and support for reflection and interactions with other teachers. Although in some countries teachers' engagement in professional learning communities formed by colleagues and professional development teams is proliferating (for example, in USA; see Nelson 2008), this is not generally the case, and it is certainly not the case in Brazil. It is worth noting that some educational research groups in Brazil have been implementing action research programs in order to surpass these problems, but in general they only involve relatively few teachers (Damasceno et al. 2001; Fiorentini 2004; Maldaner et al. 2006).

In order to increase the impact of our work on teachers' professional development, we implemented in 2007 ComPratica, an online network intended to establish a virtual community of practice involving biology teachers and biological education researchers.[1] We

[1] ComPratica can be accessed at http://www.moodle.ufba.br/course/view.php?id=8823. Even though visitors cannot post messages, they can read all the messages contained in the forums of the community and, thus, get a clear picture of how it functions. Those interested in participating in ComPratica should write to the authors of the paper. The language used in the community is Portuguese.

were stimulated by the prospect that communities of practice seem to be potentially interesting vehicles for a contextualized and continued professional development (Wenger 1998), although there are just a few experiences in science education. Moreover, due to the fact that the community is virtual, one can customize it for an extended group of teachers, with their burden of work and diverse work time schedules (Barab et al. 2002; Schlager et al. 2002). In this paper, we report results obtained in the first 2 years of the project, with the goal of inquiring into (a) characteristics that may indicate that ComPratica is effectively functioning as a community of practice, and (b) changes in teachers' professional development resulting from the involvement with ComPratica and how they may contribute to the decrease of the research–practice gap.

## Science Teachers' Professional Development and the Research–Practice Gap

Due to the centrality of teachers' skills for improving classroom instruction and the fact that they cannot be fully acquired during initial training only, several models of teachers' professional development have been elaborated and tested. The more recent and, from our point of view, more promising are the ones that incorporate a socio-cultural perspective. Research findings related to this perspective indicate that an effective teachers' professional development is characterized by being career-long in nature, developed in a specific context, based on the teacher's own work, centered on students' learning, and adapted to the teacher's professional developmental stage (Putnam and Borko 2000; Little 1993; Darling-Hammond 1997). The ideal is that teachers should become progressively more prepared to develop, implement, and share practices, knowledge, and values that answer to the needs of all their students. From a socio-cultural perspective, professional development is the result of a collaborative effort: teachers should receive support from a network of peers, researchers, school authorities, and external experts, through programs of professional development centered on school and informal activities (Schlager and Fusco 2004).

In science education, we have some good examples of initiatives for teachers' development based on collaborative effort, such as the successful SINUS project (Ostermeier et al. 2010), a German program for teachers' professional development aimed at improving science and mathematics education. This project is based on a perspective of situated learning and is implemented at a large scale. A group of experts developed a series of modules to increase the efficiency of mathematics and science instruction. Schools in the program had to choose at least two modules to work on. Modules were not preformed teaching units or whole science or mathematics programs; rather, they outlined central aspects of a problem area and provided examples of how to overcome the identified shortcomings. Teachers had to work, then, with the modules useful to their own experience, developing and evaluating putative solutions. Written materials, in-service training, and consultation from science and mathematics educators were offered to the teachers, in order to help them in developing their own classroom instruction. There are different ways of getting involved with the program, but the most basic ones are the cooperative work of science and/or mathematics teachers at a particular school and the cooperation in small school networks. The central features of this project have been adopted by similar German programs focusing on teachers' professional development in physics, chemistry, and biology (Parchmann et al. 2006; Elster 2009).

Another example is the research project on continuing professional development (CPD) described by Harrison et al. (2008). In this case, CPD programs were developed in six domains of science education, as vehicles to enhance teacher's learning through engagement

with them and the production of evidence-based portfolios about how teaching strategies in those domains were implemented and how the teachers reflected on their practice. In the first phase of the project, CPD programs were designed and piloted, either using teachers who had some expertise in the domain or leading teachers; in the second phase, the CPD programs were trialed and evaluated by experienced teachers who had only a small amount of knowledge about the specific domain; finally, in the third phase, the CPD programs were refined and then trialed again by teachers with minimal knowledge about the domain.

In both examples, specific professional development programs were tailored for teachers, by selecting the topics to be tackled, while teachers were responsible for developing or customizing, integrating, and evaluating these ideas in their specific classroom settings, with the continuous support of a network of experts and colleagues.

Looking at professional development from this situated perspective and considering the results obtained by these network efforts, it is possible to move forward and think about this approach to teachers' professional development as a vehicle to reduce the research–practice gap. This gap is generally recognized by educational researchers and teachers (Kennedy 1997; McIntyre 2005; Miretzky 2007), including the field of science education (Pekarek et al. 1996; Pena and Ribeiro Filho 2008; El-Hani and Greca 2011). Most teachers do not apply research findings in their everyday classroom work and often do not ascribe much value to the contribution of academic research to their own practices, because of what they perceive as its lack of relevance (Kaestle 1993). This gap can be seen as a consequence of the way educational research is conducted, organized, and/or disseminated (Kennedy 1997), and, also, as McIntyre (2005) puts it, as a problem of relating two contrasting kinds of knowledge. Teachers' everyday work demands a kind of pedagogical knowledge that is very different from the knowledge that educational research is well equipped to provide. By "pedagogical knowledge," we mean the knowledge that directly informs teachers' practice in managing classrooms and mediating students' learning. This is "knowledge how" and is very different from the kind of knowledge to which research typically leads, which is propositional knowledge, i.e., "knowledge that" (McIntyre 2005). This is closely related to one of the reasons for the research–practice gap mentioned in the literature, namely, that research findings are typically too generalized for teachers to use them in their classrooms (e.g., Pekarek et al. 1996). Nevertheless, research-based propositions derive their value from the very fact that they are abstract, generalized, and theoretically grounded. Scientific research aims at finding ways of identifying patterns in several instances of a phenomenon so as to interpret or explain it in more general terms.

In turn, teachers have to deal from day to day with the complexity and dynamics of classroom life. Therefore, the knowledge needed by them to manage their classrooms and mediate students' learning is context-specific pedagogical knowledge, adjusted to the unique features of each class, pupil, and lesson. If research on teaching and learning is to contribute to situated teaching practices, it will have to contribute to such a pedagogical knowledge. Nevertheless, research-based knowledge cannot be simply translated into pedagogical knowledge. Several steps are needed to bridge the gap from propositional knowledge derived from research to situated pedagogical knowledge in action. Furthermore, attempts to find easy shortcuts, i.e., hasty attempts to apply research-based knowledge in the classroom are likely to be detrimental, particularly if they are carried out without taking into consideration teachers' knowledge.

Just to offer an example of the difficulty to cross the research–practice gap, let us consider the case of the development of more satisfactory views about the nature of science (NOS), a goal often assumed for science education throughout the last century (Matthews 1994). Despite the extensive research about this topic, including several theoretical proposals and

tested teaching materials, the results of their application in the classrooms are still not reliably producing the intended learning. This is due to a great extent to teachers' understandings, interests, experience, and attitudes about NOS and, also, to other contextual variables (institutional and curriculum constraints being the most relevant) that characterize the complex nature of teaching (Abd-El-Khalick and Lederman 2000; Lederman 2006).

McIntyre (2005) claims that we could move through a continuum between the contrasting kinds of knowledge produced in the everyday practice of school teaching and in academic research about educational issues. This continuum includes: knowledge how for classroom teaching, articulation of this knowledge, deliberative or reflective thinking for classroom teaching, classroom action research, knowledge generated by research schools and networks, practical suggestions for research-based teaching, reviews of research on particular themes, and research findings and conclusions. From this perspective, we need a double movement to bridge the research–practice gap: from research-based knowledge towards particular classroom settings, through the development and gradual implementation of proposals for pedagogical practice; and from teachers' knowledge towards a greater degree of generality and, consequently, an increasing capacity of adjusting pedagogical work to new situations, through teachers' reflective practice and action research. This double movement seems to be much easier if teachers and researchers are brought together in truly collaborative and hierarchically flat research teams, such as the ones that can emerge from a community of practice.

## Communities of Practice, Research–Practice Gap and Science Teachers' Professional Development

A community of practice (CoP) is defined by Lave and Wenger (1991) as a group of individuals with distinct sets of knowledge, abilities, and experiences, who are actively involved in collaborative processes, sharing information, ideas, interests, resources, perspectives, activities, and above all, practices, in order to build both personal and collective knowledge (see also Wenger 1998). A CoP can be also conceived as "a persistent, sustained social network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history and experiences focused on a common practice and/or mutual enterprise" (Barab et al. 2002, p. 495). When a CoP is effectively working, it generates and appropriates a shared repertoire of ideas, goals, and memories. Moreover, it develops resources, such as tools, documents, routines, vocabularies, and symbols, which bring with them, to some extent, the knowledge built up by the community. In other words, a CoP involves *praxis*: shared ways of doing and approaching those things that are of interest to the people who constitute it. This is the reason why CoPs are more than ordinary groups, even though they are constructed as groups. One of the most remarkable differences between an ordinary group and a CoP lies in the very *sense of community*, in which the members invest and to which they contribute with shared projects and values (Wisker et al. 2007). The concept of CoP is derived from a view of learning as a social rather than an individual process. From this perspective, in order to learn one needs to participate, actively becoming involved in social processes, resituating or recontextualizing (and not only translating or transposing) the meaning of formal descriptions and prescriptions while carrying out a given task.

Teachers' appropriation of research-based knowledge as a way of improving their professional practice may depend on situated generalization, as discussed by Simons et al. (2003). That is, teachers are more likely to appropriate knowledge produced by research

conducted by individuals they recognize as reliable and trustworthy peers. This is more likely to happen, in turn, if they take the latter to be participants of the same CoP in which they are themselves engaged. Simons and colleagues acknowledge this connection between CoPs and situated generalization, by arguing that it is more likely that communities of practice—in comparison with metaphors of acquisition—help us in understanding how research-based insights can lead to improvements in teaching and students' achievement.

Sociological and anthropological researches have documented the characteristics of CoPs and how their members work together and build their relationships (Barab and Duffy 2000; Brown and Duguid 2000; Lave and Wenger 1991; Wenger 1998). CoPs have also been the subject of extensive and relevant debate, focusing, for instance, in issues of language and power inside these communities (Barton and Tusting 2005), or how CoPs' members can go beyond sense-making, conceived as a restricted form of reflective learning, towards critical reflective learning (Ng and Tan 2009).

Even though CoPs can be observed in many professional settings, they are rarely found among teachers (Schlager and Fusco 2004). As teachers often get isolated in their classrooms and become closed to reflection about their practice, pedagogical work tends to be a solitary activity, offering few opportunities for them to engage in collaboration and even to improve their professional development. This situation can be potentially overcome through the construction of CoPs, as environments in which teachers can reflect collaboratively about specific teaching practices, contents, interaction patterns, etc., bringing to the fore their own doubts and offering suggestions to their peers (Dalgarno and Colgan 2007). In this manner, CoPs may allow them to collectively reinvent their practices. This becomes even more probable if critical reflective learning emerges in teachers' CoPs, making it more likely that they appraise their own practices and challenge their assumptions (Ng and Tan 2009).

In sum, CoPs can be seen as potentially adequate tools for teachers' professional development and have been indeed proposed as powerful catalysts for the improvement of teaching practices (Lieberman 1996; Rényi 1996; Vanderlinde and van Braak 2010). The feasibility of using CoPs to achieve these goals has been shown by some relatively recent applications, such as teachers' communities for preparing pre-service teachers working towards secondary teacher certification (Barab et al. 2002; Eick and Dias 2005), the online CoP TAPPED-IN (Schlager et al. 2002), and Connect-ME, a virtual community of practice for mathematics teachers (Dalgarno and Colgan 2007).

CoPs formed by teachers and researchers can be an instrument for catalyzing the double movement required to diminish the research–practice gap. On the one hand, they can stimulate teachers to move from pure practitioner knowledge to the incorporation of research-based knowledge, through a process of reflective learning and action research in their classrooms. On the other hand, they can make researchers shift from investigations focused merely on their own interests and motivations to studies focused on the classroom environment and arising to a significant extent from teachers' concerns. From this perspective, CoPs may function as laboratories for generating proposals for classroom research drawing on both teachers' and researchers' knowledge and for involving them together in testing these proposals through classroom use. After all, CoPs directly meet one of the conditions favoring knowledge creation in schools that Hargreaves (1999) identified, namely, the production of recurring opportunities for reflection, dialogue, inquiry, and networking. They also satisfy other conditions mentioned by this author, in particular, the creation of a culture of continual improvement, the deconstruction of hierarchies usually found in schools, and in the relationships between schools and universities, the informality of relationships, and the tinkering and experimenting with new ideas. CoPs can be a developmental environment which side-steps, as proposed by Hargreaves, bureaucratic structures

and act as the test-bed for the restructuring of school and teacher practices. Nevertheless, there are few studies about how CoPs can be built with science teachers and science education researchers, how can professional development take place within them, and how can they be an instrument to help bridging the gap between research and practice.

ComPratica, the online environment focused on biological education discussed in this work, was implemented by the History, Philosophy, and Biology Teaching Laboratory, affiliated with the Institute of Biology, Federal University of Bahia, in Brazil, drawing on a previous experience carried out in Spain (García et al. 2008). This experience was developed assuming that an effective improvement of science teaching depends on the collaborative engagement of science education researchers and science teachers and students in a CoP (Greca and González 2002). In this previous study, a virtual community of practice was created to answer to the demand of a group of kindergarten teachers from a public school in Aranda del Duero (Burgos, Spain) for introducing science experiences in their courses. It is worth stressing that the teachers had very little knowledge about science subjects and felt their pedagogical knowledge was not enough to deal with them. The project lasted one academic year and involved all the teachers from that school (primary and kindergarten teachers), as well as a group of researchers in science teaching from the University of Burgos and the Federal University of Rio Grande do Sul (Brazil). The teachers were encouraged to propose the themes, activities, and time schedule. The science education experts helped them, through an intensive dialogue by means of online chats and forum discussions, in improving the original activities by drawing both on their scientific and pedagogical knowledge and the contributions from science education research. Both the demand for advice and the main ideas emerged from the practitioners, who tailored the researchers' recommendations to their specific settings. As the researchers considered that they took too much time helping the teachers, one of the lessons from that project was that it is necessary to include graduate students focused on science education in order to produce sustainable communities, that is, communities that can survive and evolve without the continuous support from the team that has launched it. Besides, the "knowledge how" shown by the teachers during the implementation of the science experiences was considered very useful for pre-service teachers.

In the construction of ComPratica, we benefited from this previous experience, which generated knowledge on how to handle virtual communities aiming at bridging the gap between research and practice and contributing to teachers' professional development. This online network includes high school in-service biology teachers, pre-service biology teachers, science education graduate students and researchers, and undergraduate and graduate biology students, all of them interested in secondary biological education, but with quite different backgrounds and professional training. We also gathered together in the community experts from the field of science education and from several biological fields that could contribute to the discussion of content knowledge in the community, mainly in genetics, evolution, and ecology.

The intention underlying the creation of ComPratica was to constitute a true community of practice, where the members could freely participate, focused on high school biology teaching, exchanging information, doubts, theoretical and practical knowledge, true classroom problems, and also, building possible solutions for them. This is the reason why ComPratica does not have predetermined activities. If ComPratica evolved as a CoP, such activities would appear naturally, as solutions to the specific and situated problems faced by the teachers. We would be able to see, then, the potential of a CoP for improving science teaching. This does not mean that we did not stimulate participation and discussions. We did so, but not to the extent of predetermining or even directing the activities that take place in

ComPratica. Moreover, those encouragements were needed at some point, but became gradually less necessary.

Moreover, one of the goals of the community was to promote the emergence of teaching sequences by stimulating further discussion and action regarding suggestions for teaching addressed by the members (especially, in-service and pre-service teachers) in messages sent to the forums. To build collaborative action research projects around these teaching sequences performed by teachers and educational researchers gathered in hierarchically flat groups was also an intended outcome since the very beginning of the community. This collaborative work can play a role in bridging the research–practice gap by both leading to concrete proposals that are investigated in classroom situations and creating proper conditions for a double movement—from research to practice, and vice versa—that can promote a dialogue between research-based knowledge and practitioner knowledge. By means of these collaborative efforts, we intended to pursue a further outcome of ComPratica with regard to educational research and science education improvement.

## General Description of ComPratica

ComPratica was designed to be an online network, since it is quite difficult to gather teachers together in face-to-face meetings, as a consequence of their diverse work time schedules. The virtual environment was grounded on the idea of a cooperative learning environment capable of promoting multidirectional communication, recording of the contents produced by the collaborative group, sociability, and collective intelligence (Cunha Filho et al. 2000). It was intended to be a web environment allowing diverse ways of interacting: asynchronous communication through forums, which is the main media for communication in ComPratica; synchronous communication through chats, when it is necessary to talk more intensely and collaboratively about some topic; systems for storing files, allowing for easy recovery of documents such as articles and teaching materials; and environments for collaborative authorship such as blogs and wikis, in which members can work online in a collaborative manner to elaborate texts and other materials. All members receive the forum messages in their personal mailboxes. There is also a mechanism of access control, both for keeping a recording of the members' participation and avoiding undue access.

Based on these characteristics, we chose the Virtual Learning Environment Moodle™ (http://moodle.org) as a platform to implement ComPratica. It is user-friendly; entirely available in Portuguese at our university, which also has a support group for its use; implemented in PHP, thus without system requirements that cannot be matched by the computers available to teachers, either in their schools or homes; and does not need a very fast internet connection to be properly used.

The community is focused on high school biology teaching. When the data for the present paper were collected, it included 6 forums: (1) news forum (which informs the members of events of interest), (2) forum about evolution teaching, (3) forum about genetics and cell and molecular biology teaching, (4) forum about ecology teaching, (5) forum about general issues related to science teaching, and (6) forum about botany teaching. The first five forums were proposed by the research team as a manner of focusing the community on those topics in which a more productive collaboration between teachers and researchers in our group could take place, since these topics are the ones in which the research group is specialized. Nevertheless, once ComPratica was launched, we made it clear for the teachers that more forums could be proposed if they deemed necessary. This indeed happened when some members proposed that a forum about botany teaching would be an interesting addition to

the community. Afterwards, two additional forums have been created, one on the teaching sequences built in the community and another to prepare face-to-face meetings organized by teacher educators involved in ComPratica and the pre-service biology teachers enrolled in their training courses. However, they were not included in this study, since they did not exist when the data were gathered.

Face-to-face meetings are carried out at least once a year, in order to discuss how the online environment is functioning; to plan action research projects, or to analyze data gathered during the classroom research projects; or to present specific resources, such as teaching sequences or materials, either produced by the community itself, or resulting from some meeting, journal, or other source.

As one of the desired goals of ComPratica is to lead to pedagogical innovations in schools, it was important to include in its functioning some ways of generating a climate of collaboration inside the schools where the participating teachers worked. This is essential not only because of the need for close collaboration for the teachers' effective engagement in innovation, but also as a way of empowering teachers so that they could face possible resistance of their peers, school administration, and even students and parents (cf., for instance, Miretzky 2007). For this reason, we demand that at least three to four teachers from the same school enter together in the community of peers. Nevertheless, we also adopt a flexible position with regard to teachers who do not succeed in engaging their school peers in the initiative. In these cases, they enter alone in the community and we are attentive to the problems they may have to deal with in their schools.

A question we would like to stress is how we have been managing the differences between researchers and teachers that could put at risk our objectives. Three months after the beginning of ComPratica, a face-to-face meeting was organized and putative reasons for the silent participation (which we will describe in the "Results" section) emerged in the discussions with the teachers. The two major reasons concerned the fear of being criticized and the fact that the researcher who was most actively stimulating participation did not guide the discussions in the online environment. With regard to the teachers' fear of criticisms, we increased our efforts to stimulate participation and discussed in several moments the nature and purpose of the community, seeking to create a more comfortable environment for participation. After all, as Miretzky (2007) stresses, teachers need to feel safe enough to accept looking vulnerable in front of students, colleagues, and researchers. As we will see in the "Results" section, we have indications that ComPratica came to be a comfortable environment for the teachers to expose their views and feelings.

Concerning the expectation that the discussions were guided, we made it clear both in face-to-face meetings and in exchanges in the virtual community that ComPratica is intended to be a hierarchically flat community of peers, differing in nature from a group advised or coordinated by some of its members. It was explained to them that it was not to be expected that someone oriented the discussions in the community, but, rather, the interactions would follow the paths chosen by their members. Certainly, despite our intentions, it will take a long time to deconstruct the social roles typically assumed by teachers and researchers. We have been striving for reaching this deconstruction by constantly emphasizing the characteristics of ComPratica as a community of peers, as well as by putting in the agenda discussions on the very roles ascribed to teachers and researchers, schools and universities in our societies. This is a task that should be constantly carried out, in order to overcome the feeling among teachers that "… the researchers are experts and we're all afraid to open our mouths" (as said by a teacher interviewed by Miretzky 2007, p. 275).

One of our main goals is to examine whether and how ComPratica can be an effective vehicle to improve teachers' professional development and to diminish the research–practice

gap in secondary biological education. With this goal in mind, we address in this paper the following questions with data available after 2 years of functioning:

(1) Is ComPratica indeed functioning as a CoP? If so, what are the characteristics responsible for this?

(2) What changes in teachers' professional development occur when biology secondary teachers and science education researchers, among other members, participate together in the virtual community ComPratica? Are these changes related to a rapprochement between research and practice?

## Methodology

Although ethnography is the common methodological technique in anthropology for understanding communities (Barab et al. 2002), we use a broader qualitative methodological approach, since we are dealing with a virtual community, which we cannot observe in the same way that one can do in non-virtual communities. Together with our engagement in the community as researchers and participants, our continuous monitoring of the messages posted in the forums and the field notes of face-to-face meetings, we used several additional procedures for recording information, which will be described in more detail below.

### Description of the Participants

ComPratica was initiated on November 27, 2007. In February 2010, the community was composed by 87 members, including 32 high school in-service biology teachers (4 of them also graduate students), 13 pre-service biology teachers, 17 university teachers (9 also graduate students), 12 graduate students who were not involved in teaching, 9 undergraduate students, and 4 members who were engaged in other activities. In Appendix A, we show the qualification, teaching years, taught disciplines, and educational level at which they work for 45 members out of the 50 enrolled in the community who work as teachers (with the addition of 2 pre-service biology teachers who were already working at the high school level). The members who are teachers ranged from 3 months to 37 years of experience and were teaching at a variety of educational levels, from the primary school to higher education. Most of them worked at the high school level, which is indeed the main focus of the community.

When the community was launched, it had only seven members, five of them responsible for its implementation, and most of the activity concerned testing the Moodle™ platform. Following the initial invitations, between the end of November and mid-December 2007 high school teachers and members of the laboratory (senior researchers, doctorate and master students) entered the community, which reached 28 participants. In August 2008, it reached 44 members. This was a consequence of invitations made to pre-service biology teachers from two Brazilian public universities (Federal University of Bahia and State University of Feira de Santana). In October 2009, ComPratica reached 83 members, mostly as a result of invitations to high school biology teachers across the country, by means of a public announcement about the community in a discussion list for biology teachers maintained by the Brazilian Association of Biology Teaching (SBEnBIO, http://www.sbenbio.org.br/). We planned this step by step entry having in mind the perturbations that new members can produce in a CoP (Wenger 1998).

## Data Collection and Analysis

The participation in ComPratica and the actions performed by its members were determined by analyzing the data collected by the several resources provided by the Moodle™ platform. We obtained reports about the date of entrance and the whole set of actions of each participant of the community (for instance, reading a message, downloading a file, accessing a chat, etc.), including which participants initiated threads of discussion with more than one message, until April 10, 2009, i.e., after one and a half year of existence of ComPratica. We could not gather reliable reports of the sets of actions of each participant for the subsequent months, due to a problem in the storage of the data in the Moodle™ platform of our university. With the available data, however, we were able to produce a picture of the distribution of the participation among the ComPratica members, considering several possible actions.

To determine the activities carried out in the forums, we retrieved all the written messages during the first 2 years, building a database with a total of 893 messages from the forums—excluding the news forum—summing up 498 single-space sheets.

This database was analyzed through an inductive process, having in mind the activities that define a CoP according to the literature (Lave and Wenger 1991; Wenger 1998; see the "Communities of Practice, Research–Practice Gap and Science Teachers' Professional Development" section). After reading the database as a whole, each researcher, with his or her notes of the daily monitoring, established criteria for classifying the messages in categories. After each researcher independently produced these criteria, they were discussed and determined by consensus. This process led to the categories of activities shown in Table 1 (see the next section). After the criteria were established, both researchers independently classified all the messages of the database with this categorization scheme. A message could fall into a single or several categories; for example, a member could reflect about her experience by tackling a theme in the classroom and, at the same time, share with other members useful sources of information. The inter-rating score in this classificatory process was 91 %, showing a high degree of agreement between the independent researchers' analyses. The results from these analyses (regarding the participation in ComPratica and the activities performed by its members during the first 2 years of existence) address our first question, whether ComPratica have been effectively functioning as a CoP, because they probe the defining characteristics of a CoP.

For the question related to the process of teachers' professional development and the decrease of the research–practice gap that may be occurring in the community, we used two different sets of data. Using the database described above, we determined the themes tackled in the virtual environment that may contribute to professional development. This analysis, together with those related to the participation and the activities carried out, can give clues about whether professional development is indeed happening in the community. Moreover, they can also indicate if this process is in fact contributing to reduce the research–practice gap. The themes were categorized with a similar procedure to that used for the activities, with an inter-rating score between the researchers of 95 %. The categories of themes are shown in Table 2 (see next section).

We also strived for deepening our understanding of some high school teachers' development during the period by using, besides their recorded actions in the database, written records of the face-to-face meetings and teachers' answers to written questionnaires. We analyzed this material looking for clues about the professional development favored by ComPratica and integrated these clues with the analysis described above.

**Table 1** Categories of activities performed by the ComPratica members in the forums

| Category | Description | Example |
|---|---|---|
| To pose problems or questions | One or several of the community members pose a question to be discussed, or a problem, looking for a shared solution. These problems and questions can be general in nature or connected with their experiences. | "The environmental problems generated by unbridled consumption (…) have been producing several problems in a variety of spheres. In view of this, to understand the functioning of the web of nature and its ecological processes is of the utmost importance, since it makes the student perceive the impact of human action in the natural environment. And what is up to us as biology teachers? Are we contributing to educate citizens with conducts compatible with 'sustainable development'?" (CF, May 24, 2009) |
| To ask for help or information | The members ask for information, either in general terms, or to solve a particular doubt. | "I do not know if [these textbooks] can be used as reading assignments for high school students, I did not think about them from this perspective yet. What do you think?" (CNE, March 1, 2009) |
| To share information | The participants are directed to sources of information taken by other members to be reliable or of good quality, or events, texts and other resources are shared by the members. | "Ah, I was forgetting –I considered this post-doctoral work to be interesting.'S-cience and art united against racism'. Cordel [a kind of popular poetry from the Northeast of Brazil] uses ideas from the geneticist Sérgio Pena to fight against the notion of races in the human species. http://cienciahoje.uol.com.br/noticias/arte-e-ciencia/cienciae-arte-unidas-contra-o-racismo" (MIB, February 28, 2009). |
| To share knowledge (theoretical, practical or experiential) | The participants make knowledge or personal experiences available to other members. This category can be regarded as characteristic of this kind of community, composed by both practitioners and researchers from the fields of biology and biological education. | "Indeed, the textbooks do not offer support to develop this historical-philosophical approach to science that we desire so much. Our education is also VERY insufficient in this regard. I can say that I did not have a single discipline during my whole undergraduate studies that tried to look at the sciences from this perspective." (LCO, February 27, 2009). |
| | | "I think what is lacking are texts like the one I have in the book 'Secret Sex' by Cláudio Picazio. He gives information to the teachers concerning diverse themes (each chapter a theme) – and then we have a scientific text explaining (to the teachers), for instance, about the composition of sexuality. Subsequently, we have a text or activity that can be used with the students. I read an article by Jimena Furlani that does something like that. Besides providing theoretical grounds, she suggests some activities to be carried out with the students. I adapted some that I am using." (MIB, February 28, 2009) |

**Table 1** (continued)

| Category | Description | Example |
|---|---|---|
| | | "To deal with that, we need a historical approach that departs from the so-called original Darwinism, which followed the acceptance of the Darwinist theory, passes through the neo-Darwinism of the end of the 19th century and beginnings of the 20th century, with its insistence on natural selection as the single mechanism that explains evolution, and its conflicts with neo-Lamarckism,. . ." (CNE, February 26, 2009) |
| To reflect upon one's own practice | The members reflect upon their practices, as well as recognize the difficulties and solutions that they have found in their own teaching practices. | "But I believe it is because it takes so long to produce a small text that is accessible to the students that many teachers who work, like myself, more than 50 h per week in the classroom (and we still have the classes at Saturday) end up using only the textbook." (MIB, February 28, 2009) |
| To propose and/or carry out concrete actions | The participants propose or carry out some concrete actions in order to solve a problem, or communicate his or her intention of collaborating in the execution of some action. | "Who knows this is not the opportunity for us to produce texts like this [addressing historical-philosophical issues about science]? Very slowly, making use of the experience and availability of the participants of this group. We need a starting kick. Then, does someone volunteer????" (LCO, February 27, 2009) |
| To express feelings | The members exchange emotion-laden statements about their education and teaching practice, as well as expressions of sympathy for the experiences of others. | "I don't even remember my classes about evolution in the undergraduate studies. It is sad, isn't it? But it is true!!" (ACS, March 1, 2009) |
| To stimulate participation | It comprises actions carried out to promote participation and/or keep in motion a discussion about a certain theme (stressed by Wenger [1998] as a key element for the construction of a CoP.) | "People, we need to confirm the new Chat! It is a very pleasant and productive activity. Let's try to reach a consensus about an optimal schedule" (VAP, May 23, 2008) |
| To manage participation in a community activity | The participants send messages aimed at managing their participation in some activity of ComPratica. | "I noticed that most of the people opted for Saturday. Is there a definitive date? I would like very much to go to the meeting [a face-to-face meeting of the community], but since I do not live in Salvador and with the beginning of the teaching year getting closer, I need to organize myself in advance" (VRE, February 8, 2010). |

We used several examples from the same exchange, as a way of giving a clue about the dynamics of the discussion in the community. (Data from November 27, 2007 to February 21, 2010)

**Table 2** Categories of themes addressed in the ComPratica forums

| Category | Description | Examples |
|---|---|---|
| Challenges of teaching biology or science | In this category we included messages that discussed the difficulties faced by biology or science teachers in their classrooms, dealing either with those difficulties in general terms, or in more specific terms, such as those considering challenges of teaching a particular subject matter or concept. | "As a single question—which does not refer specifically to your great teaching sequence, but to the way of teaching evolution in high school in general—I would like to ask your opinion about the risk of promoting among the students a simplistic identification of the theory of evolution with Darwinism, when we now know that the evolutionary theory goes much beyond the neo-Darwinist claims. I think the high school students are perfectly capable of understanding the differences between macro- and micro-evolution, and, also, that the mechanisms regulating both processes are essentially different. What do you think of this question?" (JSA, February 21, 2010) |
| Teacher education | This category comprises messages concerning teacher education, including reflections about the teachers' own experiences. | "The teachers I meet speak of the same education I've had and also feel difficulties when they teach evolution, some even avoid discussions between the conceptions of the origins of species by a creator and speciation" (IS, July 24, 2009) |
| Educational themes | In this category, we included messages addressing other matters related to education, besides challenges in teaching biology/science and teacher education. | "I have been thinking about the relationship between my pedagogical conceptions, my teaching practices, and the students' learning. A question I have been raising for myself, based on some readings, is the following: Are my teaching conceptions consistent with the students' needs?" (CNE, October 28, 2009) |
| Conceptual issues related to biological knowledge. | Messages about conceptual issues, which were sent by both teachers and researchers, were included in this category. | "I do not know if it is possible to develop in a sustainable manner. First, we need to make it clear what we consider to be 'developed'. Which parameters we use to say that something is 'developed'. This can vary, from place to place". (MIB, June 2, 2009). |
| Teaching sequences and other pedagogical resources | In this category we included messages about teaching sequences and other pedagogical resources built both within and outside the community. | "The idea is to work with subjects related to the different groups of living beings through the construction of an interpretive trail (by the students themselves), always focusing on the ecology of the groups. We have an area of Atlantic Rain Forest available (…) |

**Table 2** (continued)

| Category | Description | Examples |
|---|---|---|
| | | to develop this project. We are thinking in the teaching sequence for this work, because I am responsible for the second grade class and he, for the third grade. (…)" (LCO, February 27, 2009) |
| Beginning teachers' tensions and conflicts in the transition to practice | This category is composed by messages about the pedagogical practices and the tensions and conflicts experienced by beginning teachers, in particular, pre-service teachers in transition to practice. They typically show pre-service teachers asking for the help of their peers, most of all, of the more experienced teachers in the community. | "I began to give classes in a public school, with the discipline Health and Social Welfare. It is a new discipline, it began to be taught in the school this year and there I was informed that they do not have a teaching plan for it and the teacher who was teaching it was building the plans for the teaching units. I have this challenge now: to build plans for the 3rd and 4th units. I investigated in the site of the Ministry of Education, I found good suggestions of classes and themes (…). I would like to ask you, if you can, to suggest different themes and activities to carry out with the students, because I do not want to only explain things" (LCR, July 27, 2009) |
| Research–practice gap and ComPratica as a way of diminishing it | This category is composed by messages that raise the very question of the research–practice gap and discuss ComPratica as a way of facing it. | "To cast a new look at the education of 'our children' aiming at a high quality education will only be possible with the joint work of researchers and teachers. I believe we already had a good start with the work this community intends to develop" (ACS, May 9, 2008). |
| Dissemination and discussion of texts, media programs, internet resources and, occasionally, academic sources | This category includes messages informing the members of ComPratica about such resources. | "In the link below, you will find an Atlas of Histology that ACS shared with us and probably interests the teachers in the community" (CNE, January 19, 2009) |
| Announcements of courses and meetings | In this category, we gathered messages informing about courses and meetings related to education or biology. | "The Smile School, with its partners, will promote the II International Meeting for Social Inclusion" (ACS, May 30, 2008) |
| Operation of the community | This category comprises messages addressing operational aspects of the community itself, such as those combining when chats would take place, discussing problems in the usage of some resource, etc. | "Yes, it is like SNS said, everything fits into our conversation here, provided it is about biology teaching, primary school fits too, of course!" (CNE, November 11, 2008) |

(Data from November 27, 2007 to February 21, 2010)

## Results

### Participation in the Community

Taking into account the recordings of the whole set of virtual actions until April 10, 2009, it is clear that there is a large variation in the members' degrees of participation. Five members (7.8 %)[2] showed the greatest number of actions in the community, ranging from 998 to 2,101 recordings, including all kinds of actions, not only writing messages. Three of them are high school teachers (VAP, ACS, DFA), one is a pre-service teacher (MAL), and the other is one of the researchers (CNE). These three in-service teachers were quite active participants, writing many messages both in forums and chats, initiating threads of discussions, proposing topics for the chats, and engaging in the construction of teaching sequences for classroom action research. There was a second group of members (20, 31.2 %)[3] with participation ranging from 91 to 990 recorded actions, many of them high school and pre-service teachers.

The pre-service teacher with a high number of actions (MAL) illustrates a mode of participation that needs a closer look. It was a silent participation, in the sense that we did not see her writing many messages or explicitly engaging in many activities. Nevertheless, by checking the recordings of her participation, we discovered that she was constantly accessing the community, reading through most of the sent messages. Not surprisingly, she ended up engaging in quite an active manner in several classroom action research projects that emerged from the community and subsequently began to write an increasing number of messages, showing how she moved from a more peripheral (at the point we gathered the data) to a more central participation in ComPratica.

The available data highly underestimates this silent participation, since all members receive the forum messages in their personal mailboxes and, thus, can be participating silently without ever entering the community. In these cases, we can have no recording of their participation. We need to use, thus, other means of assessing silent participation. One of them is the engagement in the chat sessions carried out in ComPratica because it is an activity that cannot be followed unless the members access the community. We can consider, for instance, the cases of AMO (a high school teacher) and INC (an undergraduate student), who had on average just 100 recorded actions, but participated in several chats.

Figure 1 shows the distribution of participation in ComPratica until April 10th 2009 in a manner that considers silent participation with greater precision, since it takes into account the members' involvement with activities playing a central role in the community. Members are distributed in circles according to their levels of participation as indicated by recorded actions in the Moodle™ platform. We should consider, however, other activities that show an effective engagement of the members, as a way of including silent participation, such as (1) engagement in the construction, implementation, and testing of teaching sequences (MDG, CMU, CS, CF, CP, VRE, LCO, LCC, IS); (2) frequent initiation of threads of discussion (CS, MIB, LCO, LCC, IS); and (3) involvement in the maintenance of the community (IG). We reach, then, the figure of 16 out of 64 members (25 %) with a strong engagement at April 2009. The arrows included in Fig. 1 show these participants who move to a central position in ComPratica through their involvement in a number of actions that are significant to its functioning.

We can describe this silent participation observed in ComPratica as a legitimate peripheral participation (Lave and Wenger 1991). This kind of participation is characteristic of

[2] This percentage was calculated considering the number of members at April 2009 (64).
[3] Considering the number of members at April 2009 (64).

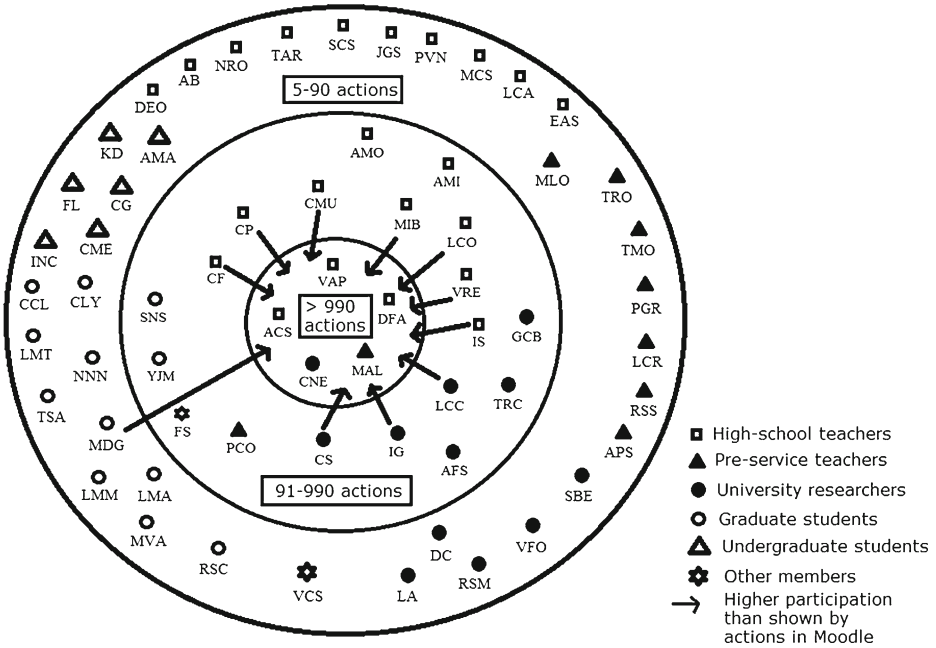


**Fig. 1** Diagram showing the levels of participation of ComPratica members. Each member is represented by an acronym containing two or three letters. The *outer circle* includes members ranging from 5 to 90 recorded actions in the Moodle™ platform. The *intermediate circle* shows members ranging from 91 to 990 actions. In the *inner circle*, we show members with more than 990 actions. Diverse kinds of members are indicated by different geometrical figures, as shown at the right side. When the member was both a teacher and a graduate student, we gave preference to represent him or her as a teacher. The *arrows* indicate members with a level of participation which is higher than that indicated by the number of recorded actions in Moodle™. The criteria to identify these members are discussed in the text. Data from April 10, 2009

communities of practice and plays an important role in professional and personal development. It can be conceived as a process of social learning in which members gradually engage in exchanges and practices, moving from a partial to a full participation in the community. The case of MAL, discussed above, is a good example of this kind of participation. Nevertheless, we observed this movement several times in ComPratica, particularly in the case of in-service and pre-service teachers who engaged more and more in classroom action research, even though they began (and some of them remained) without writing much in the community.[4]

[4] As we remarked above, there was a problem in the storage of the data and we were not able to obtain reliable reports of the participants' actions in the period from April 2009 to February 2010, when we gathered the data for this paper. We did not perceive, however, any important change in the community dynamics throughout these months and, thus, we can infer that the community kept showing the same pattern in the levels of participation observed in the data gathered until April 2009. To sustain this inference, we can look, for instance, at the activity in the forums: from November 2007 to April 10th 2009, 514 messages addressing topics to be discussed were sent to ComPratica, while from April 10th, 2009 to February 21st, 2010, 379 messages were sent. That is, in the first period, approximately 30 messages were sent per month, on average, while in the second, the average amounted to 34 messages/month.

A total of 893 messages were sent to the forums until February 21st, 2010 (on average, ca. 32 messages/month). The forums that attracted most of the attention were those related to general issues about science teaching (54 %) and to evolution teaching (27.3 %), which are also the ones with the highest level of participation (2,202 and 1,834 recorded actions in Moodle™ until April 10th, 2009, respectively). Significant levels of participation were also seen in the case of the forum on genetics and cell and molecular biology teaching. The forum on ecology teaching, in turn, showed a different pattern, leading to more actions of reading than of writing messages. Finally, the forum on botany education included until February 21st, 2010 only nine messages.

In the forums, 44 out of 87 members have participated. CNE was the participant who wrote more messages in the period, as a consequence of the fact that he is one of the researchers responsible for stimulating participation, an activity which is a key element in a CoP (Wenger 1998). The members who sent more messages after him were all high school teachers, followed by a pre-service teacher and two graduate students affiliated to the research group, who are also university teachers. If we now consider the initiation of threads of discussion by the members of the community, considering only threads that indeed resulted in subsequent discussion, we see that 18 members (ca. 20 %) initiated threads of discussion, including 11 high school teachers, 2 pre-service teachers, 4 graduate students (3 also university teachers), and 1 university teacher. Many of the threads initiated by the teachers and graduate students gave origin to prolonged discussions in ComPratica.

Regarding the participation in the chats, the highest number of participants (11) was observed in a chat about the transition from teacher education to science classroom practice. The other chat on the same topic attracted five participants. These chats emerged out of discussions in the forum on science teaching elicited by pre-service teachers who were worried about the tensions and conflicts that mark the first years of work as beginning teachers (e.g., Price and Valli 2005; Smagorinsky et al. 2004). In these discussions, it was remarkable the number and relevance of the interactions between pre-service and in-service teachers. We believe that the quality of these interactions and the significance of the theme for the teachers in the community (both in-service and pre-service) explain the degree of participation in these chats. In order to illustrate the discussions in the chats, we reproduce below an exchange that took place in one of them[5]:

> AMO (pre-service teacher, in transition to classroom teaching[6]): Currently, I am experiencing some difficulties, because I have been trying to use in the classroom what I learn in the university. But it becomes complicated, because the whole school goes on in the same regime - test and examination - and valuing subject matters that I do not consider to be important to the students' education. What can I do?
> PCO (pre-service teacher, in transition to classroom teaching): Well, at the moment I feel very anxious, above all because I never had experiences as a teacher. The things are too much in theory only, and the expectation is really to manage to teach with efficiency, as it was already discussed in a forum, making it possible the understanding of reality and the capacity to change it.
> (…)
> CNE (researcher, university teacher): AMO and PCO, with regard to how one can transfer what was learnt in the university (the 'theory') to the classroom, it is natural to

[5] The messages sent in the community were freely translated by the authors of the present paper, with care being exercised with regard to the preservation of their content and, as much as possible, style of writing.
[6] The classification of some participants of the chats does not correspond to that shown in Fig. 1 because the chat took place before April 10th, 2009.

find many limitations. Schools have a series of codes and controls, norms, which constrain the possibilities of the teacher's work. (…). In the face of these codes, norms, and controls, teachers will need to find their way of innovating. Here the role of utopias enters, in my view. We have to create a utopia about how would be the ideal teaching for us and, with this goal in view, act in the present so as to reach it. The goal is indeed unreachable, but it can guide us, regulate what we want to do in the present. Then we can go on walking step by step, even if short steps, in the direction of what we want. In order to be satisfied and in peace with this, we must rejoice in each small step, not only with the hard complete change… What do you think?

JGS (in-service high school teacher): This is what I have been doing along these 17 years working in high school, you learn that to transmit contents is not the most important, what is important is how the student learns.

VAP (in-service high school teacher): A problem to be considered is to learn to deal with the norms and try to manage the goals.

PCO: But JGS, and what about what we should achieve regarding contents? Because if we do not achieve what we are told to, how will we be seen by the institution?

(…)

JGS: PCO, you should give priority to the stage where your student is, and in agreement with your colleagues manage what is better for her… there is no point in advancing with the contents if my student is not ready for the next step.

VAP: My transition was slow, shifting from a teacher who reproduced textbooks, focused on the contents not on people, to a teacher worried about the citizen that I thought and think I am preparing for life… I have made some discoveries in this path and I have been evaluating myself… I am myself still in the way…

This dialogue went on with rich utterances concerning school norms, students' knowledge, teaching goals, and so forth, but we think the excerpt above is enough to exemplify the kinds of exchanges between in-service and pre-service teachers (and also researchers) that have been taking place in ComPratica.

The second chat with the highest number of participants (8) was focused on a conceptual issue, namely, the distinction between two kinds of functional traits that can be found in living beings, adaptations and exaptations (Gould and Vrba 1982). However, the discussion shifted to another topic that constantly raises interest in the community: the difficulties faced by biology teachers when addressing evolution in the classroom. A chat about the inclusion of students with special needs in science classrooms was also carried out, prompted by the very active participation of a biology high school teacher who has extensive experience with special needs students. There were three other chats, directed towards discussing teaching sequences developed in ComPratica.

As shown in this description, if we consider the members having in mind their professional status, the group that, in the period analyzed, sent more messages in the forums and initiated more threads of discussion was the group of high school teachers. Moreover, this group and one of the pre-service teachers also showed the highest participation in the chats. These results show a high level of engagement of a significant number of high school teachers, at least with regard to the level of participation. Nevertheless, even though the high school teachers actively participated in the forums and chats, and initiated threads of discussion, there is also an unequal participation of the members.

Participation inequality is very common in virtual communities, in which most of the members are lurkers, i.e., participants who read and observe, getting often involved in legitimate peripheral participation, but do not contribute much in an explicit manner. In

virtual communities, an adequate distribution might be 80 % of lurkers, 16 % of members contributing with some material, and 4 % answering for most of it (Nielsen 2006). In ComPratica, we observed until April 2009 a better distribution of participation, with 5 (7.8 %) members contributing with a great amount of material and 20 (31.2 %) also giving an important contribution to the community dynamics. It is true that Compratica is not intended to be a common virtual community and it is just natural, then, to expect a greater level of engagement than that observed among typical users of online communities. But, if we take in due account the teachers' burden of work and lack of time, the level of participation in ComPratica can be regarded as remarkable, far beyond our own expectations when we initiated the community. Finally, being ComPratica also an environment where, as we will describe in the next section, there is a strong exchange of information, didactical materials and conceptual discussions, many silent participants may be benefiting from their involvement with the community, even when they are not participating explicitly.

The levels of participation observed in ComPratica are relevant with regard to our first research goal, since to function as a CoP its members should exhibit a sense of community, engaging in mutual relationships and contributing to the community shared repertoire of knowledge. In order to learn as the member of a CoP, one has to participate, actively even if silently becoming involved in the social processes that take place in the community.

## Activities Performed by the ComPratica Members

A total of 1,375 activities were categorized in the messages sent to the forums of ComPratica in the period under study (see Table 1). Figure 2 shows how these activities were distributed.

The activities more frequently performed in ComPratica, at least as shown by the analysis of the forum contents, are the ones which define a CoP. The ComPratica members are actively involved in the community, sharing information and resources (to share information), ideas, interests, and perspectives (to share knowledge), and activities (to propose/carry out concrete actions,), in order to collaboratively solve problems (to pose problems or questions, and to ask for help).

The main activity of the members is to share knowledge. Moreover, they share "knowledge that" as often as they share "knowledge how." This is an important feature of the community, since in these exchanges the epistemological differences that we stressed in our initial discussion as reasons for the research–practice gap are being reconsidered and, we think, reduced. Teachers contribute with their practical knowledge in order to help others and to contextualize the "know that" from the research group and this "know that" seems to help teachers in improving their understanding of biological concepts as well as in revisiting their educational practice. For instance, in the excerpt below we find a high school teacher sharing "knowledge how" when she discusses activities she carries out to discuss osmosis in the classroom:

> I believe that the way we approach a subject partly depends on the group of students we have. In my case, I work with high school pupils who study at night. Many of my students are housemaids or housewives. Therefore, I ask them (and to the boys, if they know) when we should put the salt in the lettuce salad (MIB, May 30th 2009).

And, in the same thread, we can also find a graduate student sharing "knowledge that":

> This question, about what we should first work on, the theory or the practice, is addressed in the Didactics of Science, and we do not have a consensus, I believe it will depend on the profile of the group you're working with, and what educational theory

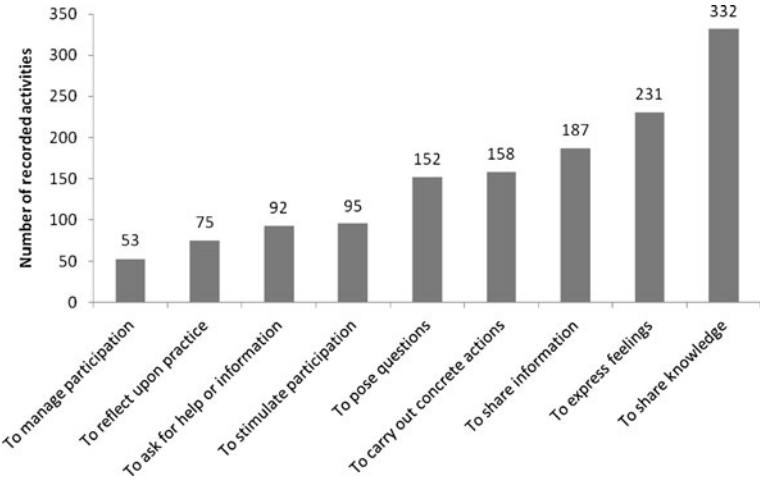


**Fig. 2** Distribution of messages sent to the ComPratica forums per activity. The categories of activities are described in Table 1. Data gathered in March 1st, 2010

> the teacher is adopting. Suppose that the question is to prompt the student for a critical and active participation aiming at meaningful learning, so that she can take what was discussed in the classroom to her everyday life, then I suggest that, even using an experimental or practical approach, you can do it in an open-ended manner (SNS, May 31st 2009).

However, graduate students, researchers and teacher educators are not the only ones sharing "knowledge that." It is not rare that teachers also do so in the community, as we can see in the following example, where a high school teacher combines in the same argument "knowledge that" and "knowledge how":

> [The] combination of different disciplines to produce knowledge (…) can be interdisciplinary or transdisciplinary. In the interdisciplinary approach, for instance, in the school: a problem-situation is created which involves five high school disciplines (…). And in the transdisciplinarity? Besides working in the interdisciplinarity, it would bring the search for solutions, cultural, ethical aspects, or, yet, knowledge that could explain the situation, at different levels of reality (Nicolescu). (IS, August 1st 2009).

Moreover, to share information is also a frequent activity in ComPratica, showing that the community is providing the members with materials that are, in general, not only posted, but also discussed, contributing to a reflection upon the members' conceptions about science teaching and biological knowledge. Some of these discussions about materials posted in the community were the starting point of teaching sequences developed in ComPratica. We can see below a discussion between two high school teachers (SRM and LCO) and a researcher (CNE) about a source of information sent by one of the community members:

> About the article on speciation without barriers sent by MIB, isn't it the case that this mechanism is similar to a sympatric speciation model? Or does it treat something differently? (SRM, July 17th 2009)
> Hi, SRM. I have the same doubt. For me, what is described is a sympatric speciation model. And there is even more. In the text, it appears that it is a case of spontaneous formation of species. This is a very strange claim. I understood that the geographic

> barrier would not be the factor capable of generating this speciation, but wouldn't natural selection be acting on this new organism? Could it be that I got all wrong? Someone could help in this respect? (LCO, July 17th 2009)
> SRM and LCO, the model is different from sympatric speciation because it depends on the range of the distribution. What the authors modeled was the fact that, if a population shows a very large distribution range, even with no barrier, gene flow decreases from one extreme to the other of the range, and speciation may happen. (CNE, July 20th 2009).

To express feelings is ranked in second place among the activities performed by the members. Considering our goals in this paper, this is an important finding, since it provides indications of the degree of cohesion reached by the community, to the extent that its members feel comfortable enough to express their emotions freely. As we stressed above, the fear of being criticized was considered one of the major reasons for the low level of participation in the initial months of the community. However, teachers have begun to feel safer in ComPratica as time progressed and this level of comfort became sufficient for them to be able to express a diversity of feelings in the community, including fears related to their practices. Possibly this is the reason for the increasing number of members writing in ComPratica as the months passed. This activity is also relevant because the empathy demonstrated for the experiences shared in the community may help teachers in overpassing, at least partly, the characteristic isolation of their work: the professional obstacles, challenges and fears are similar and the virtual colleagues express their support and hope for the success of each other.

To propose and/or carry out concrete actions was the fourth more frequent activity in the community and was mainly related to the construction of teaching sequences. The messages included in the category to stimulate participation had been sent both by the research team and by other members of the community, importantly including high school teachers. The goal of these messages was to stimulate participants to engage in ongoing discussions. We have noticed, as desired, that this activity has been decreasing in importance as the community gets more and more mature.

Finally, let us discuss the category to reflect upon one's own practice. Although it is controversial whether CoPs can indeed engage teachers in critical reflective learning (Ng and Tan 2009), we have found many messages that are difficult to include in any other category and seem, in our view, to indicate that reflective learning is indeed taking place in ComPratica. Here are two examples of messages from high school teachers that support this claim:

> … CNE reminds us that the spheres of decision making are not in our hands. If the responsibility for the change is not in our hands, as educators we can contribute to the kind of person we want to help to educate. What kind of person do we want to educate? To do what? How? With what purpose? As a science educator, I want her to think in science, to leave high school with a notion of the science that we do, recognizing the contribution of scientific knowledge to our lives, perceiving the presence of science in everyday life, for instance, not only that an aqueous solution of sodium chloride provides an electrical circuit, but also that two metal wires bring light into the house. A general view of perceiving science as a whole, as well as the importance of specific knowledge (IS, February 1st 2009).
> … I agree (…) about the mismatch between what the LDB[7] says and what really happens in high school. What we see throughout the years is a teaching entirely

[7] LDB: "Law of Guidelines and Bases for National Education" (Lei de Diretrizes e Bases da Educação, number 9394/96). This is the most general legal background for the organization of education in Brazil.

> directed towards raising the indices of approval in the universities' entrance examinations, and an illusion that we are educating critical and reflective citizens. Our pedagogical practice is frozen into a linear curriculum with an enormous weight of content, memorization, and simulated tests as training for the examinations, and we still say that we are evaluating… We dream with a different teaching, but we do not know either where to begin, or what direction to take (VAP, January 30th 2009).

This kind of message involves a critical look on how the personal or general educational practice is and how it might or even should be. Therefore, we consider that the teachers are indeed engaging in critical reflection about their practices and are going through a learning process in the collaborative environment of the community. This is one of the reasons why we consider that ComPratica is working as a resource for their professional development. It is possible that this category appears as a consequence of one of the main features of this community, namely, that theoretical and practical knowledge are "sitting" side by side within it, contributing for this critical look on practices. We think that the atmosphere and cohesion created in ComPratica, as indicated by the high rank of the category to express feelings, also contribute to the emergence of the activity of reflecting upon practice.

It is worth stressing that, with the exception of the activity of stimulating participation, all the activities emerged in ComPratica without being imposed or proposed a priori by the research team. The results presented in this section, alongside with those from the previous section, seem to show that ComPratica have, in the 2 years analyzed here, evolved to truly become a community of practice: the levels of participation, which overcome a distribution regarded to be adequate in virtual communities, indicate that many members are actively involved in mutual relationships and sharing; the more frequent activities are those that define a CoP, information and knowledge sharing, proposal of concrete actions, problem posing, and help requesting; the expression of a diversity of feelings, including those related to practice, show that the community reached a degree of cohesion that allows it to evolve as a CoP; and, finally, both "knowledge that" and "knowledge how" are shared in ComPratica, showing its prospects of not only contributing to teachers' professional development, but also to reduce the research–practice gap.

## Thematic Analysis of the Forum Messages

Table 2 presents the categories of themes addressed in the ComPratica forums and Fig. 3 shows the distribution per theme of the messages sent to the community forums until March 1st, 2010. The discussion of teaching sequences, most of them developed in the community, was responsible for the largest number of messages (27.7 %). This shows that the community is especially focused on one of its major goals, namely, teachers' engagement in small action research projects via the collaborative construction and testing of teaching sequences and their respective instructional materials. Even though teaching sequences and pedagogical resources constructed outside the community were also discussed, most of the messages were devoted to the discussion of the teaching sequences collaboratively built inside it, that is, sequences proposed by the high school teachers as result of their specific needs and developed by them collaboratively with other teachers, researchers, undergraduate biology, and graduate science education and biology students.

Although we will not discuss here the teaching sequences or their classroom applications (which will be addressed elsewhere), some brief comments are worth doing. Thirteen teaching sequences, with related instructional materials, were being discussed in ComPratica at the time the data were gathered, at diverse levels of development. These teaching sequences emerged organically as a consequence of members' participation in ComPratica,

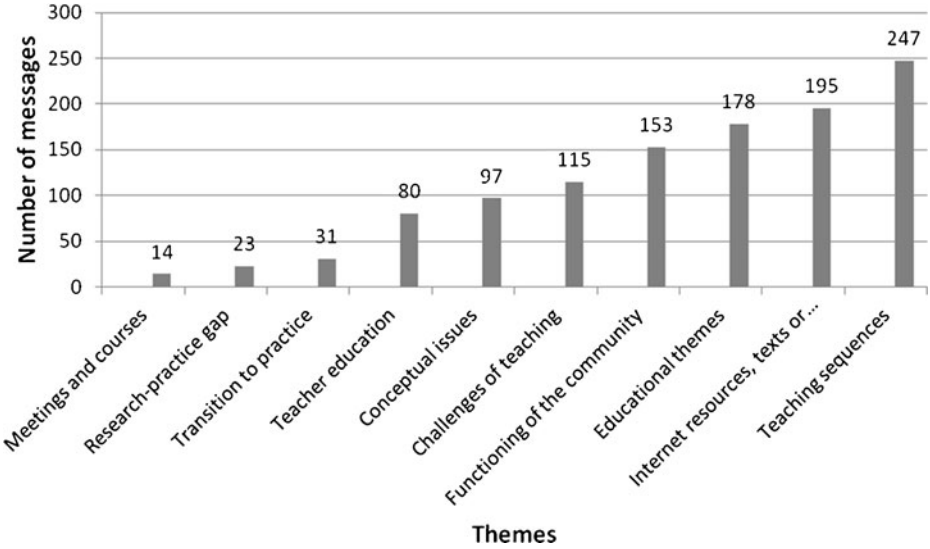


**Fig. 3** Distribution of messages sent to the ComPratica forums per theme. The categories of themes are explained in Table 2. Data gathered in March 1st, 2010

being initially provoked by messages sent to the forums. They were discussed within the community and four of them were used as platforms to build action research projects involving high school teachers who are members of the community. While the origins of these teaching sequences are located in ComPratica, further research on them took part by means of an interaction between a collaborative research group (gathering high school teachers, pre-service teachers, educational researchers, and graduate/undergraduate students) and the virtual community. As the collaborative research group grew as an endeavor in its own right (which will be addressed elsewhere in detail), we can say that the professional development of the teachers engaged in the initiative discussed in this paper can take place at two levels: while there is (a) a common experience of professional development for all teachers engaged in the virtual community, (b) some of the teachers undergo an experience of professional development by means of both ComPratica and the collaborative research group. Ten teachers (from three different public schools, located in different cities) were involved in the collaborative educational research when the data for the current paper were gathered, but this endeavor has been steadily growing since then, as the research group obtains more and more experience in managing this effort, and an increasing number of teachers and schools gradually enter the collaborative group. Now (at May 2012), it comprises 17 teachers from 8 schools.

The collaborative research group mentioned above received funds through a project approved by the Research Support Foundation of the State of Bahia (FAPESB) and Anísio Teixeira Institute (IAT), an organ of the state Secretary of Education responsible for teacher training. This provided substantial support to the action research projects. Seven high school teachers received grants for their research activity and three schools where teachers engaged in the community work received funds to build research centers on science education. The teaching sequences tested in this project address the teaching of the theory of evolution by natural selection at the high school level by means of a historically and epistemologically informed approach, which also involves the analysis of socio-scientific decision making

situations; two interrelated interdisciplinary teaching sequences on energetic metabolism (in biology classes) and chemical reactions (in chemistry classes), using popular science texts for contextualizing the content in relation to students' everyday knowledge and socio-scientific issues; and a teaching sequence on the current environmental crisis (with an emphasis on global warming) and the functioning of the Earth system, using scientific controversies on Gaia theory and Earth System Science to treat the content in an epistemologically informed manner. These results also add to the outcomes for educational research and science education improvement resulting from ComPratica, since their ultimate origin lies within the community.

Together, the messages from the dissemination of categories and discussion of texts, media programs, internet resources and, occasionally, academic sources and announcements of courses and meetings amount to 23.4 %. They are related to the sharing of materials that contribute to the improvement of teaching practices. Educational themes were discussed in 19.9 % of the messages, including general topics that worry teachers, such as the current reforms of high school in Brazil, the inclusion of special needs students in the science classroom, problems found in science textbooks, the paucity of the historical treatment of science content in classrooms and textbooks, the organization of science curricula, etc. The functioning of the community also deserved a lot of attention of its members (17.1 % of the messages), mainly related to the organization of activities such as face-to-face meetings and chats. The most interesting of them, however, are those in which the members propose new kinds of activities to be carried out in ComPratica, showing their involvement in improving the community. This was the case, for instance, of a graduate student/university teacher who proposed that the community might have a specific locus for the members to upload texts reporting their classroom experiences or research results:

> Friends and colleagues, what about a space to report our experiences, specifically in the form of publications, ideas for publications in meetings, journals? (GCB, October 23th 2008)

A forum specifically focused on the teaching sequences built and discussed in ComPratica has been subsequently established, partly taking account of this proposal.

Among the educational issues discussed in ComPratica, we stress teacher education (9 %) and challenges of teaching biology or science (12.9 %), due to their central importance in the proposal of professional development underlying the community. These discussions deserve attention because of the frequent occurrence of reports of the teachers' feelings about the difficulties faced in teaching, which often led to reflections about the quality of their pre-service education:

> The evolutionary ideas in my education were those mentioned by CNE: Lamarck, Darwin, and natural selection. And today I still find teachers, more recently graduated, who also show the same difficulties in teaching evolution. (…). I worked with the textbook content. Initially, I asked questions in the blackboard, made use of classification schemes and cladograms, teamwork, expositions and dialogues. This last way of approaching the theme was precarious and today I think it should be further explored, but my diffidence was the limit (IS, July 24th 2009)

This seems to be particularly important for beginning teachers in their transition to practice (3.5 % of the messages). The pre-service teachers participating in ComPratica often appeal to the experienced teachers, as well as to the members who are teacher educators, in search of advice about their first experiences as teachers. It is worth remembering that the

chat about this topic was the one with the highest participation. Below, we offer an example of a pre-service teacher's plea for help of the experienced teachers:

> Hello, it is in reality a request for help. I am a Biology pre-service teacher and I was invited by a colleague who teaches for some time to give some classes on the evolutionary theories in her seventh-grade class.[8] (…). I feel very insecure to approach this theme in the seventh grade, maybe because I did not have experience in this school year, or, else, because we work with evolution teaching at higher education in a way that is a bit distant from primary school. What do the teachers advise me? What kind of approach? What discussions might arise? How to deal with them? (MAL, November 10th 2008)

Conceptual issues (10.9 % of the messages), quite deep and assorted, were discussed mainly as a consequence of questions posed by the high school teachers. For example, a discussion about evolution as tinkering lasted for one month and a half, actively involving 7 members, who exchanged 17 messages. In 2 years of functioning, there were conversations in the community about the role of evolutionary thought in biology, the nature of learning in the science classroom, the role of tinkering (in opposition to design) in evolution, the relationships between science and religion, and the nature of scientific methods. Such discussions can be illustrated by the exchange on speciation reproduced in the previous section.

They stimulated the exchange of materials as well as teachers' reflections upon their undergraduate instruction and, in some cases, as quoted above, the subsequent development of teaching sequences. We cannot assert, from the analysis reported in this paper, that the teachers belonging to ComPratica have improved their conceptual knowledge—although this is true in the case of the teachers who are developing teaching sequences. Nevertheless, the discussions about conceptual issues in the forums and chats may have allowed the teachers to perceive that their doubts were generalized and contributed for the appropriation of concepts superficially addressed during their education.

Finally, the research–practice gap and the role of communities of practice in facing this problem also received some attention in the community (2.6 % of the messages). This is shown by the following commentary by a high-school teacher about their collaboration with a university researcher:

> Yesterday, CS and I finished our work in the school. (…). It was very pleasant to have the opportunity of seeing my discourse in the classroom. It was a rare opportunity of perceiving a full interaction between a university teacher-researcher and a basic education teacher. I wish this opportunity is repeated, since only in this way we will be building perspectives for improving science teaching (VRE, November 21st 2008)

Another example is offered by the following exchange between a researcher and a high-school teacher:

> Hi LCO and others, there is no doubt we face problems with the spread of research results… it is not really reaching the teachers. This is the so-called research-practice gap. Our motivation to create ComPratica was precisely to look for more tools to overcome this gap (CNE, March 6th 2009).

[8] In Brazil, the seventh-grade corresponds to the year 8 of Primary Education, planned to enroll students around 13 years of age.

> I agree with you. I believe ComPratica comes to bridge this gap… The changes can only happen gradually!!!! Unfortunately for anxious people like ME… (LCO, March 8th 2009)

We would like to highlight two features from the results obtained through this thematic analysis. First, there are many messages in which teachers exchange materials that they may use to improve their lessons. Second, in the discussions related to teachers' work and worries, a variety of subjects was addressed. These features show how mutual relationships between the ComPratica members were established, mediating an exchange of knowledge and information among them, which can provide, in turn, support for teachers' practice and professional development. Teachers seem to consider ComPratica as an appropriate space for building conversations on the complexity of the teaching task, their work, knowledge, concerns, and so forth.

## Teachers' Professional Development in ComPratica

The results presented in the previous sections show that ComPratica reached during its first 2 years of functioning the intended goals regarding the professional development of biology high school teachers and the construction of conditions that may lead to a decrease of the research–practice gap. These outcomes are particularly noticeable in the case of the development and investigation of teaching sequences, which are good examples of how ComPratica may be helping in an effective professional development: they emerged from the teachers' critical reflections about some aspects of their reality, made possible by the community; are focused on the teachers' classrooms and are developed, as small action research projects, by the teachers themselves within a supportive network of peers and researchers in science education; and in this network, a collaborative approach to educational research engaging teacher-researchers and university researchers emerged. In order to develop the action research projects, the teachers feel the urge of improving their scientific and research-based knowledge in science education. These projects also stress the double movement needed to reduce the research–practice gap: from research-based knowledge towards particular classroom settings, through the development and gradual implementation of proposals for pedagogical practice; and from teachers' knowledge towards a greater degree of generality and, consequently, an increasing capacity of adjusting pedagogical work to new situations by means of teachers' reflective practice.

Summing up, the following results of the analyses presented here provide an affirmative answer to our second research question, showing important clues that ComPratica is indeed becoming an effective tool for teachers' professional development (and, also, researchers' professional development), as well as to bridge the research–practice gap:

- Sharing of both "knowledge that" and "knowledge how," making practice- and research-based knowledge come closer within the community.
- Openness of teachers and researchers about their own practices.
- Access to materials that teachers may use to improve their lessons.
- Co-construction with peers and educational researchers of teaching sequences (most of them as a result of actual classroom needs).
- Participation in small action research projects focused on these teaching sequences, opening the teachers' classroom and personal theories for investigation.
- Pre-service teachers' access to pedagogical knowledge from experienced teachers and teacher educators.

## Concluding Remarks: Implications for Science Education Research and Science Teaching Practice

In 2003, Gordon remarked that research about the effectiveness of online communities of practice in improving teaching practices were anecdotal at best, emphasizing the need for more concrete data. The results reported in this paper advance in this direction. The first question of our research was whether ComPratica can be characterized as a community of practice after its first 2 years of functioning. The participation and activities performed in it fulfill several of the characteristics that define a CoP. Inside ComPratica, new ideas and tools are germinating, promoting teachers' and researchers' professional development, helping its members to have access to ideas, methods, content, and, above all, peers. Moreover, the CoP seems to be supporting beginning teachers in the difficult transition to practice, providing conditions for their learning about the profession, not only by actively participating in the exchanges that take place in the community, but also by means of legitimate peripheral participation (Lave and Wenger 1991). It is interesting to note that, after the period analyzed in this paper, a member of the community have coined a new term, 'ComPraticos', which continues to be used by part of the members to refer to themselves. If we compare the results obtained in ComPratica with those concerning other successful CoPs, we observe in the former the same characteristics emphasized by Dalgarno and Colgan (2007) in the CoP Connect-ME: ComPratica has been providing a suitable environment for teachers to share knowledge, resources and personal experiences, to obtain reliable materials for their classes—supplied by both researchers and other teachers—, to communicate about teaching experiences, feelings, doubts with their peers in a safe and reassuring manner, and to develop personal experiences of learning. Even though we cannot analyze here the trajectory followed by the CoP after the period in which we gathered the data for this study, it is worth mentioning that, now, as we finish reviewing the paper (May 2012), ComPratica reached more than 4 years of age and is still very active with even greater levels of participation of its current 173 members.

Concerning the possible role of CoPs in improving teacher professional development, we identified several clues that point in this direction. The influence of the CoP on teaching practice becomes possible in its affirmative environment because shared understandings are reached by its participants and, moreover, suggestions for improving practice that make sense for the teachers are produced by means of a dialogue in which effective participants contribute a body of knowledge that is explicitly taken into account. In this manner, ComPratica has generated a shared repertoire of ideas and resources, which carries the knowledge that the community has built throughout its functioning and has been changing the practices of the peers who collaborate within it. This is yet another characteristic of a CoP that is satisfied by ComPratica (Lave and Wenger 1991).

In their work, Dalgarno and Colgan (2007) highlight the necessity of more research aiming at understanding the role played by collaboration in giving support to teachers' classroom practices. In ComPratica, we find a collaborative attempt to answer problems that arise in the teachers' situated pedagogical practices. These collaborative practices become evident in the emergence of action research projects, which resulted mainly from teachers' contributions to discussions in the forums and involved in varying degrees a co-constructive process by means of exchanges within the community.

Two characteristics of ComPratica seem to be novelties in the literature about CoPs aiming at teacher professional development: the emergence of collaborative action research projects and of critical reflective learning. We detected in ComPratica several

clues indicating that at least part of its members may be going beyond the restricted form of reflective learning that Ng and Tan (2009) call sense-making.

Regarding the research–practice gap, our conclusion is that CoPs can be invaluable tools for decreasing the distance between research and practice in science education. In particular, this can happen if they incubate collaborative research initiatives carried out inside teachers' classrooms, engaging university researchers, teacher-researchers, graduate and undergraduate students in peer teams striving for flattening the usual hierarchies found in educational studies, where teachers are more often seen as consumers rather than producers of knowledge (Garrison 1988). However, the prospects of bridging the research–practice gap in ComPratica are not limited to the action research projects, but extend to the collaborative and affirmative environment that has been established, in which its members feel safe enough to express feelings and engage in critical reflective learning, in such a manner that both teachers and university researchers end up questioning their roles in the educational system and, in particular, how they assume particular positions in relation to one another.

The proposal of teachers' virtual CoPs is based on the premise that it is possible to engage them in online meaningful and productive professional discursive interactions (Schlager et al. 2002). Our results give support to this premise and, just as Schlager and colleagues, we see teachers reaching inside the CoP a number of goals that previously seemed to be possible only if they were involved in face-to-face meetings, such as brainstorming, decision making, information sharing, and knowledge construction. Given the teachers' workload, online communities may be a particularly powerful way of reaching these results, so as to overcome the typical isolation of teachers in their classrooms and engage them in professional development, practitioner research, and collaborative critical reflection. Nevertheless, we cannot reach, through our research results on ComPratica, sufficient information regarding how the participation in the CoP may be modifying, if it does, the teaching practice in the case of those teachers who do not participate actively in the community and are not engaged in action research projects.

The results discussed in this paper make us feel confident that CoPs in science education can be an important tool in facing one of the greatest challenges for teacher professional development, namely, the construction of a knowledge base for the teaching profession that can continuously grow and improve, based on the dialogue between practitioner knowledge and research-based knowledge (Hiebert et al. 2002). We do not think, however, that CoPs (virtual or not) can be simply *the* solution, or some sort of panacea for all the problems faced by science education and science teacher professional development. We only consider that in our specific context—currently a group of 173 teachers, students, and researchers focused on high school biological education in Brazil—ComPratica showed itself to be an effective tool for professional development and joint research, diminishing the gap between the research and the practice conducted by its members. We do think, however, that this example can be multiplied in other places and, thus, it is worth investigating CoPs in science education as a way of providing teachers and university researchers with adequate conditions for collaborative research and professional development, by taking into account the needs, possibilities, difficulties, shortcomings found in the teachers' classrooms and researchers' investigations, and at the same time, going beyond a collection of recipes for science teaching.

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## Appendix

**Table 3** Some information about the teachers participating in ComPratica (Data from February 2010)

| CoP member | Qualification | Teaching years/ months | Taught disciplines | Educational level of current teaching |
|---|---|---|---|---|
| ALI | Pre-service biology teacher | 6 months | Biology | High school |
| ALA | In-service biology teacher | 10 years | Biology and Chemistry | High school |
| AMO | In-service biology teacher | 7 years | Biology | High school |
| ACS | In-service biology teacher | 10 years | Biology | High school |
| AFS | Chemical engineer, Master in information science | 30 years | Computer science | Higher education |
| CLY | Psychologist, Philosopher, Master in psychology | 6 months | Psychology | Higher education |
| CMU | In-service biology teacher | 9 years | Biology and Chemistry | High school |
| CNE | Bachelor in biology, Master and Doctor in education | 17 years | History and philosophy of biology | Higher education |
| CS | Bachelor in biology, Master in history, philosophy, and science teaching | 16 years | Teacher education | Higher education |
| CP | In-service biology teacher | 2 years | Biology, Teacher education | High school and higher education |
| DEO | In-service biology teacher, Master in science and mathematics teaching | 10 years | Biology, Teacher education | High school and higher education |
| FAS | In-service biology teacher | 7 years | Biology | High school |
| GCB | Biology, Master in history, philosophy, and science teaching | 8 years | Teacher education | Higher education |
| GBO | Bachelor in biology, Master and Doctor in pathology | 18 years | Cell and molecular biology | Higher education |
| IS | In-service science teacher, Master in science teaching | 19 years | Biology, chemistry, science | High and primary school |
| IG | Physics, Master and Doctor in physics | 10 years | Teacher education | Higher education |
| IZC | Biology, Master in history, philosophy, and science teaching | 20 years | Teacher education | Higher education |
| JAN | In-service biology teacher | 10 years | Biology, chemistry, and philosophy | High and primary school |
| JGS | In-service biology teacher | 20 years | Biology | High school |
| JES | In-service biology teacher | 1.5 years | Biology | High school |
| JBU | In-service biology teacher | 8 years | Biology, chemistry and science | High and primary school |
| LAS | In-service biology teacher | 5.5 years | Biology and science | High and primary school |
| LBA | In-service biology teacher | 10 years | Biology, physics, and science | High and primary school |
| LCC | Bachelor in biology, Master in ecology and biomonitoring | 7 years | Ecology | Higher education |
| LA | Pedagogy, Master in history, philosophy, and science teaching | 14 years | Teacher education | Higher education |
| LMT | Biology, Master in history, philosophy, and science teaching | 3 months | Teacher education | Higher education |

**Table 3** (continued)

| CoP member | Qualification | Teaching years/ months | Taught disciplines | Educational level of current teaching |
|---|---|---|---|---|
| MRA | Bachelor in biology, Master in cell biology | 20 years | Teacher education | Higher education |
| MCL | In-service biology teacher | 10 years | Biology | High school |
| MEP | Biology, Master in environmental sciences, Doctor in education | 26 years | Teacher education, History and philosophy of biology | Higher education |
| MAL | In-service biology teacher | 1 year | Science | Primary school |
| MTA | Bachelor in biology, Master in history, philosophy, and science teaching, Doctor in education | 4 years | Teacher education | Higher education |
| MIB | Bachelor in biology, in-service biology teacher, Master in education | 20 years | Biology and science | High and primary school |
| NRO | In-service biology teacher | 18 years | Biology and chemistry | High school |
| NNN | Bachelor in biology, Master in history, philosophy, and science teaching | 3 months | History and philosophy of biology | Science education |
| RAB | Pre-service biology teacher | 6 months | Biology | High school |
| ROO | Biology, Master and Doctor in Education | 24 years | Teacher education | Higher education |
| RSM | Bachelor in biology, Master in history, philosophy, and science teaching | 2.5 years | Teacher education | Higher education |
| SBE | Physics, Master in education | 37 years | Teacher education | Higher education |
| TCO | In-service biology teacher | 15 years | Science | Primary school |
| TRC | Biology, Master in education | 23 years | Teacher education | Higher education |
| TAR | In-service biology teacher | 8 years | Biology and science | High and primary school |
| TFA | In-service biology teacher | 8 years | Biology and Environmental education | High school |
| VFO | Biology, Master in history, philosophy, and science teaching | 14 years | Teacher education | Higher education |
| VAP | In-service biology teacher | 20 years | Biology | High school |
| VCS | Bachelor in biology, Master in history, philosophy, and science teaching | 1 year | Teacher education | Higher education |
| VRE | In-service biology teacher, Master in agricultural science | 10 years | Biology | High school |
| VIA | Bachelor in biology, in-service biology teacher | 14 years | Biology | High school |

## References


Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: a critical review of the literature. *International Journal of Science Education, 22*, 665–701.

Barab, S. A., & Duffy, T. M. (2000). From practice fields to communities of practice. In D. Jonassen & S. Lands (Eds.), *Theoretical foundations of learning environments* (pp. 29–56). Mahwah: Erlbaum.

Barab, S. A., Barnett, M., & Squire, K. (2002). Developing an empirical account of a community of practice: characterizing the essential tensions. *The Journal of the Learning Sciences, 11*, 489–542.

Barton, D., & Tusting, K. (2005). *Beyond communities of practice: language, power and social context.* Cambridge: Cambridge University Press.

Borko, H., & Putnam, R. (1996). Learning to teach. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 673–708). New York: Macmillan.

Briscoe, C. (1991). The dynamic interactions among beliefs, role metaphors and teaching practices. A case study of teacher change. *Science Education, 75*(2), 185–199.

Brown, J. S., & Duguid, P. (2000). *The social life of information*. Cambridge: Harvard Business School Press.
Cunha Filho, P. C., Neves, A. M., & Pinto, R. C. (2000). O Projeto Virtus e a construção de ambientes virtuais de estudo cooperativo. In *Ead.br: Educação a distância no Brasil na era da internet* (pp. 53–72). São Paulo: Ed. Anhembi-Morumbi.
Dalgarno, N., & Colgan, L. (2007). Supporting novice elementary mathematics teachers' induction in professional communities and providing innovative forms of pedagogical content knowledge development through information and communication technology. *Teaching and Teacher Education, 23*, 1051–1065.
Damasceno, A. M., Abreu, N. G., & Mercado, L. P. L. (2001). *Formando o professor pesquisador de ensino médio*. Maceió: UFAL.
Darling-Hammond, L. (1997). *Doing what matters most: investing in quality teaching*. Kutztown: National Commission on Teaching and America's Future.
Eick, C., & Dias, M. (2005). Building the authority of experience: the development of preservice teachers' practical knowledge through coteaching in inquiry classrooms. *Science Teacher Education, 89*(3), 470–491.
El-Hani, C. N., & Greca, I. M. (2011). Participação em uma comunidade virtual de prática desenhada como meio de diminuir a lacuna pesquisa-prática na educação em biologia. *Ciência & Educação, 17*(3), 579–601.
Elster, D. (2009). Biology in context: teachers' professional development in learning communities. *Journal of Biological Education, 43*(1), 53–61.
Fiorentini, D. (2004). Pesquisar práticas colaborativas ou pesquisar colaborativamente? In M. C. Borba & J. L. de Araújo (Eds.), *Pesquisa qualitativa em educação matemática* (pp. 487–504). Belo Horizonte: Autêntica.
García, J., Greca, I. M., & Meneses, J. (2008). Comunidades virtuales de práctica para el desarrollo profesional docente en enseñanza de las ciencias. *Revista Electrónica de Enseñanza de las Ciencias, 7*(2), 439–462.
Garrison, J. (1988). Democracy, scientific knowledge, and teacher empowerment. *Teachers College Record, 89*, 487–504.
Gordon, D. (2003). Linking teachers with technology: online courses and communities provide ways of delivering professional development and support. *Harvard Education Letter, 19*(6), 1–4. http://www.hepg.org/hel/article/256. Accessed 4 October 2011.
Gould, S., & Vrba, E. S. (1982). Exaptation—a missing term in the science of form. *Paleobiology, 8*, 4–15.
Greca, I. M., & González, E. (2002). Comunidades de aprendizaje en desarrollo sustentable. In: *Actas del XX Encuentro de Didáctica de las Ciencias Experimentales* (pp. 231–238). La Laguna, Spain: Universidad de La Laguna.
Hargreaves, D. H. (1999). The knowledge-creating school. *British Journal of Educational Studies, 47*, 122–144.
Harrison, C., Hofstein, A., Eylon, B.-S., & Simon, S. (2008). Evidence-based professional development of science teachers in two countries. *International Journal of Science Education, 30*(5), 577–591.
Hiebert, J., Gallimore, R., & Stigler, J. W. (2002). A knowledge base for teaching profession: what would it look like and how can we get one? *Educational Researcher, 31*, 3–15.
Kaestle, C. F. (1993). The awful reputation of educational research. *Educational Researcher, 22*, 23–31.
Kennedy, M. M. (1997). The connection between research and practice. *Educational Researcher, 26*, 4–12.
Lave, J., & Wenger, E. (1991). *Situated learning: legitimate peripheral participation*. New York: Cambridge University Press.
Lederman, N. G. (2006). Nature of science: past, present, and future. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 831–879). New York: Routledge.
Lieberman, A. (1996). Creating intentional learning communities. *Educational Leadership, 54*, 51–55.
Little, J. W. (1993). Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis, 15*(2), 129–151.
Lüdke, M., Puggian, C., Ceppas, F., Cavalcante, R. L. A., & Coelho, S. L. (2001). *O professor e a pesquisa*. Campinas: Papirus.
Maldaner, O. A., Zanon, L. B., & Auth, M. A. (2006). Pesquisa sobre educação em ciências e formação de professores. In F. M. T. Santos & I. M. R. Greca (Eds.), *A pesquisa em ensino de ciências no Brasil e suas metodologias* (pp. 49–88)). Ijuí: Unijuí.
Matthews, M. R. (1994). *Science teaching: the role of history and philosophy of science*. New York: Routledge.
McIntyre, D. (2005). Bridging the gap between research and practice. *Cambridge Journal of Education, 35*, 357–382.
MCT (Ministry of Science and Technology). (2010). *Consolidação das recomendações da 4ª Conferência Nacional de Ciência e Tecnologia e Inovação para o Desenvolvimento Sustentável; Conferências nacional, regionais e estaduais e Fórum Municipal de C, T&I*. Brasília: MCT/CGEE.

Mellado, V. (1998). La investigación sobre el profesorado de ciencias experimentales. In E. Banet & A. de Pro (Eds.), *Investigación e Innovación en la Enseñanza de las Ciencias (vol.I)* (pp. 272–283). Murcia: Diego Marín.

Miretzky, D. (2007). A view of research from practice: voices of teachers. *Theory into Practice, 46*, 272–280.

Nelson, T. H. (2008). Teachers' collaborative inquiry and professional growth: should we be optimistic? *Science Teacher Education, 93*, 548–580.

Ng, P. T., & Tan, C. (2009). Community of practice for teachers: sensemaking or critical reflective learning? *Reflective Practice, 10*, 37–44.

Nielsen, J. (2006). Participation inequality: encouraging more users to contribute. In *Nielsen's alertbox column on web usability*. http://www.useit.com/alertbox/participation_inequality.html. Acessed 4 October 2011.

Ostermeier, C., Prenzel, M., & Duit, R. (2010). Improving science & mathematics instruction—the SINUS project as an example for reform as teacher professional development. *International Journal of Science Education, 32*(3), 303–327.

Parchmann, I., Gräsel, C., Baer, A., Nentwig, P., Demuth, R., & Ralle, B. (2006). Chemie im Kontext—a symbiotic implementation of a context-based teaching and learning approach. *International Journal of Science Education, 28*(9), 1041–1062.

Pekarek, R., Krockover, G., & Shepardson, D. (1996). The research/practice gap in science education. *Journal of Research in Science Teaching, 33*, 111–113.

Pena, F. L. A., & Ribeiro Filho, A. (2008). Relação entre pesquisa em ensino de física e a prática docente: Dificuldades assinaladas pela literatura nacional da área. *Cadernos Brasileiros de Ensino de Física, 25*, 424–438.

Price, J. N., & Valli, L. (2005). Preservice teachers becoming agents of change: pedagogical implications for action research. *Journal of Teacher Education, 56*, 57–72.

Putnam, R., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4–15.

Rényi, J. (1996). *Teachers take charge of their learning: Transforming professional development for student success*. Washington, DC: National Foundation for the Improvement of Education. http://www.eric.ed.gov/PDFS/ED401251.pdf. Accessed 4 October 2011.

Schlager, M. S., & Fusco, J. (2004). Teacher professional technology, and communities of practice: are we putting the cart before the horse? In S. Barab, R. Kling, & J. Gray (Eds.), *Designing virtual communities in the service of learning* (pp. 235–256). Cambridge: Cambridge University Press.

Schlager, M. S., Fusco, J., & Schank, P. (2002). Evolution of an on-line education community of practice. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities: learning and change in cyberspace* (pp. 129–158). Cambridge: Cambridge University Press.

Simons, H., Kushner, S., Jones, K., & James, D. (2003). From evidence-based practice to practice-based evidence: the idea of situated generalization. *Research Papers in Education, 18*, 347–364.

Smagorinsky, P., Cook, L. S., Moore, C., Jackson, A. Y., & Fry, P. G. (2004). Tensions in learning to teach: accommodation and the development of a teaching identity. *Journal of Teacher Education, 55*, 8–24.

Vanderlinde, R., & Van Braak, J. (2010). The gap between educational research and practice: views of teachers, school leaders, intermediaries and researchers. *British Educational Research Journal, 36*, 299–316.

Wenger, E. (1998). *Communities of practice: learning, meaning, and identity*. New York: Cambridge University Press.

Wisker, G., Robinson, G., & Shacham, M. (2007). Postgraduate research success: communities of practice involving cohorts, guardian supervisors and online communities. *Innovations in Education and Teaching International, 44*, 301–320.