

Theory and practice in a science education course for elementary teachers

Aurora Lacueva

School of Education, Central University of Venezuela, Caracas, Venezuela

lacter@cantv.net

Translation: Ainoa Larrauri

This is an Accepted Manuscript of an article published by Taylor & Francis in <i>Educational Action Research</i> on 28 Jan 2014, available online: http://www.tandfonline.com/10.1080/09650792.2013.869182 (Green Open Access)
--

Abstract

In this action research work, I analyze the theory-practice integration in teacher preparation within the context of a science and technology (S&T) education teaching methodology course aimed at future elementary teachers. The course was designed, developed and evaluated taking into account this relationship as one of its axes. The results reveal that the proposal favors progress in theory-practice integration and stimulates the students' reflection and research. By means of a written report and an oral presentation, the students communicated their reflections on S&T teaching in the context of their concomitant professional practice. They also collected and presented resources and activities they found useful for teaching, practiced the use of certain educational S&T kits, and looked for and shared S&T pieces of news from different mass media. They additionally conducted a school learning project simulation and reflected on it. Besides, they prepared three written essays about theoretical-practical assigned readings and discussed them. In this paper, I refer to achievements and difficulties that emerged during the process, relating them to other research findings in the area and to theoretical considerations. Finally, I make proposals for further efforts in this field.

Keywords: reflective teachers; theory and practice in teaching; teacher preparation; science and technology education; action research.

Introduction

The aim of this action-research (A-R) work has been to attain higher theory-practice integration in a 'Natural Science and Health Education Teaching Methodology' course belonging to the elementary teaching program of a university. As the educator in charge of the course, I designed, implemented and evaluated it taking into account this aim as one of the axes of the pedagogical initiative. Here, I describe the process and the achieved results. I also make suggestions for further improvements in theory-practice integration in teacher education.

The action-research developed not only considered this important dimension, but had also other facets which I cannot discuss in this paper: critical reflection and inquiry, the university class as a model 'at its level', the class group as a community of learning, and a

relation with science and technology of positive affectivity. My intention was to put into practice a holistic design, not one centered in only a certain aspect of the preparation of teachers, however important. Such type of design is perhaps more blurred but also more synergic and more favorable to the preparation of the students. Also, I was not interested in doing a focused (more ‘academic research-oriented’) research on one or a few aspects of teaching, but in developing an integral action-research in the interest of meaningful education for my students.

Action-research is a complex way of thinking, acting and doing research. It is difficult to present it as emerging from a small set of research questions. However, as an orientation to the readers of this paper, I could say that the question that gave birth to this research reported was: How can I design and teach a science education methods course for pre-service primary level teachers that can be feasible (in my context) and at the same time pedagogically positive? This general question then resulted in other, more precise, ones: Which should be the general (not too restrictive or rigid) objectives of the course? Which should be the basic features of this course to ensure dialectical consistency with its general objectives? Which kinds of activities should the students and I perform? What changes are needed and can be made in the material resources and physical environment of my classroom in order to develop the designed course? How can we (my students and I) make progress in the construction of a learning community? How can we meaningfully evaluate learning, teacher action and course features? And then also these questions resulted in more questions.

Of the whole set of research questions implicated, the central question considered in this report is: *How can I improve theory-practice integration within my science methods course for pre-service primary level teachers?*

This work seeks to contribute to the improvement of a particular situation, but as many A-R initiatives, it also strives to provide useful theoretical and theoretical-practical elements for those involved in Teachers’ Education in other situations.

The need of theory-practice integration

Theory and practice should not go separate ways in the preparation of teachers. However, there is usually a remarkable split between the theory studied in university courses and the reality at school, and even between the practice preached in university courses and the practice at school (Lacueva 2009a; Rodríguez 2009; Rorrison 2011). It is common to see that school routines eventually prevail over university theoretical and applied knowledge which does not show to be sufficiently linked to the educational reality, or to become as pertinent or as powerful as would be needed (Korthagen and Kessels 1999; Torres 1996). On the other hand, we have to acknowledge that the way things are done at school is the result of mighty forces that have had an impact for decades, if not centuries, not only in that field, but in other social spheres as well. Unfortunately, negative features prevail: authoritarianism, bureaucratization, standardization of school life, children as objects of adult action, knowledge as pills to be administered to passive audiences (the Freirean ‘banking education’, Freire 1972). These social features are deeply rooted and respond to predominant social interests. Besides, they easily adapt to conditions common in many schools, particularly in peripheral countries, such as overcrowded classrooms, poor infrastructure, scarce resources and low teachers’ salary, among others. Some authors refer

to ‘practice architectures’ to highlight how all practices are developed on a social ground and within certain structurizing conditions: traditions, economic system, societal organizations, history, among others (see for example Smith, Edwards-Groves and Kemmis 2010).

Yet, change is possible: At schools, universities, communities and other social organizations (even Ministries of Education sometimes!) different people strive for a democratic, investigative, critically reflexive, inclusive and diverse school life. We could say, along with the abovementioned authors, that these people are creating ‘emancipatory practice architectures’. In teacher education institutions, we are called to join in this effort and so, among other things, find a better way to proceed with theory and practice in teacher preparation. It is not a question of small adaptations here and there: Our whole curriculum should be marked by a dialectical, critical and creative approach to the theory-practice relationship. Student teachers need to learn how to manage and develop theory and practice in a coherent and mutually supportive way throughout their university preparation (Chacón 2008; Kemmis 1996). Teachers educated under this approach do not follow blind routines and/or repeat general statements, but they develop praxis —theoretically reflective and morally responsible practice— and, in a proper milieu, they can become teacher-researchers and educational theorizers (Freire 1999b).

Educational theory, or better to say, pedagogical theory is the most important theory in teacher preparation, even though there are other valuable and necessary theoretical contributions. I am not using here the term ‘Pedagogy’ in the conception prevailing in Anglo-Saxon literature, namely ‘Pedagogy as method’ (Ax and Ponte 2008; Smith, Edwards-Groves and Kemmis 2010), but in a wider sense, as it is used in the Latin tradition of ‘Pedagogy as a theoretical-practical discipline’. As a discipline, Pedagogy is not simply aimed at describing, explaining or understanding, but also at supporting and orienting a complex and multifaceted activity, namely the educational activity. At times, the discipline has been subject of a methodological and epistemological positivism that has played down many efforts through reductionism, fragmentation and simplification (Carr and Kemmis 1986). The world view and interests of powerful minorities have also influenced some pedagogical theorizing, in detriment of the majorities’ interests. Nevertheless, today we count on a long historical tradition and significant accumulated knowledge enriched by different perspectives, particularly the ones that ‘connect the moral and the empirical into a practice-oriented science’ (Ax and Ponte 2008, 10).

Teachers need to have sufficient knowledge about the field they teach and even know about the inquiry processes, the history and the epistemology of that specific field, in order to be able to adequately guide schoolchildren and facilitate their learning process. Apart from this, they should have knowledge from disciplines that will orient and contextualize their work by contributing to a better understanding of human beings, their learning skills and their behavior in the world: psychology, neuroscience, sociology, economics, anthropology, politics and philosophy. Teachers need to be aware of the impact of the temporal and spatial circumstances in which they live and of how the world outside the classroom has an influence on their work, and how their work, in conjunction with the work of many others, has an influence on the world. They have to reflect on how the economic, social, cultural and political forces that converge or collide at the local, national and global levels, affect their own lives, those of their students and the schools’ overall fate (Freire 1999a; Hussein

2006; Zeichner 1995). Additionally, they need to acquire knowledge about education as such, that is educational history, educational policies, and structure and functions of their educational system, among others.

These varied theoretical elements need to be organized and structured around the pedagogical core of teacher education. Otherwise, the different pieces of knowledge will remain dispersed, disconnected from one another, having little impact on each teacher's concrete educational work. Unfortunately, at present, university teacher education tends to minimize Pedagogy and its ramifications by directly jumping from the so-called 'educational sciences' to the teaching action, thus passing up the opportunity to orient the whole preparation around this all-embracing discipline—a theoretical current that nurtures itself from its own knowledge, but also from other fields, thereby providing for interdisciplinary and transdisciplinary approaches.

In order for the pedagogical theory—both of each particular teacher and in general—to develop more and more fruitfully, it needs to be contrasted with authentic practice in the different educational settings. Furthermore, it needs to build up a dialogical relationship with it (Kane 2002). Equally, practice needs to interact with theoretical knowledge to be enriched and become more fruitful and organic, while being, at the same time, the breeding ground for new theoretical abstractions. After all, without the teachers, it will be very difficult to develop pertinent and useful pedagogical theory. Their participation, together with that of teacher educators and other university researchers, supported by the collaboration of students, parents and communities in general, will be crucial for theory contrasting and the generation of new pedagogical theory, especially that of transforming nature (Korthagen 2007; Rust 2009). This is so because teachers are the natural actors of the educational event; they are the ones who are on the ground and who therefore have the knowledge and action capacity that external agents will hardly possess. Besides, reducing them to mere applicators of the theory and prescriptions produced by others impoverishes their professional life and degrades their work. We can find some illuminating cases of the rich contribution made by teachers acting as practitioners and theoreticians in: Bolívar et al. (1987); Ciari (1981); Díez Navarro (1998); Edwards, Gandini, and Forman (1998); Gallas (1995); Katz and Chard (2000); Lodi (1980); López and Lacueva (2008); Manning, Manning, and Long (1994); Pearce (1999); Ramos (1999); Whitin and Whitin (1997). The great French pedagogue Célestin Freinet is an outstanding example of a practitioner-theoretician (see an account of his life and work in É. Freinet 1977).

Every practice certainly entails aspects that are difficult to state explicitly or subtle knowledge that can only be learned by doing, observing or helping others who already know (Fenstermacher 1994). However, one cannot conclude from this that teaching is strictly an art, composed of ineffable and idiosyncratic knowledge that cannot or need not be theoretically backed up. Teaching does entail artistic components, but it is a complex human action that can be systematized and theorized on, and that, in fact, already counts on a significant accumulation of theoretical contributions. Therefore, teaching can neither be considered a mere technique despite its technical components. It is only by being reflected upon and systematized in some manner how practice can attain quality and transformative potential. This is very different to simply 'apply' broad theoretical statements to particular situations. It rather implies using general theoretical knowledge, good practical traditions,

situated knowledge, values, techniques, and practical wisdom (the Aristotelian Phronesis) to be able to act in the complex school world.

Right from the beginning of their preparation, student teachers should experience this theory-practice integration and get progressively involved in this relationship. This requires transformations that have to be introduced considering the curriculum design as a whole, for changing one or two courses will not suffice (Murillo 2006; Perrenoud 2001). However, any experience that can be developed in specific courses and be then reported—with all its limitations— can be helpful to shape more ambitious transformations. In this paper, I present the results of my experience trying to better integrate a university teacher education course with real educational practice in the schools.

Methodology

This work was carried out using an action research approach, concerned about promoting theoretical development along with practical transformation (Carr and Kemmis 1986; Cascante and Braga 1994; McKernan 1996; Kemmis 2010). I conducted the study within the framework of my own course—divided into two sections— throughout an academic year and based on the following stages: (i) accumulation of experiences before systematic research (previous years); (ii) design of action (before the course began); (iii) implementation, monitoring and first interpretations; and (iv) progress assessment (after the course ended). In Table 1, I present a summary of the procedures used to gather information during the research project.

(Table 1 here)

After gathering the information, I *transcribed* all the recordings and carried out the *organization* of the gathered material. Then, I analyzed each one of the seven different types of activities developed in the course, *describing* them, *interpreting* what had happened in each case, and *assessing* the contributions of each activity to the achievement of the central aim of the research study (Lacueva 2009b). In a second interpretation moment, I reconsidered the gathered data in a more abstract manner in terms of axes, which derived from both the study's theoretical grounds and my reflection on the data as such through a deductive-inductive approach (Lacueva 2010a). In this research paper, I address the axe I call 'theory-practice integration' and, partially, the axe 'stimulus to critical reflection and research'. I use the term 'axes' and not the more common 'themes' in order to highlight the structuring role they play when designing the course.

The study's credibility was pursued by means of method and source triangulation, as well as through prolonged engagement (one school year), careful description and the effort to systematically reflect on the evidence. Evidence stability or dependability was pursued through the detailed description of the gathering and interpretation work (Feldman 2007; Guba 1981). Space limitations hinder us from giving a detailed account of the accumulated pieces of evidence and force us to summarize. Yet this global approach allows for a comprehensive grasp of the change-driven action and its results.

The methodology can be characterized as action-research based on the work's following features: it rises from a need of positive change in a social practice (in this case, educational

social practice); its purpose is to generate practical-theoretical answers to this need (always tentative and partial, as any answer product of research); these tentative answers are designed and tried in naturalistic conditions; the researcher is an authentic member of the context where the research is carried out; the work is organized and systematic; theoretical reflection takes place throughout the research process; the work strives to contribute to pedagogical knowledge and practice; there is conscious attention to the institutional and social contexts where the research is developed; the investigation seeks to contribute (within its limits and together with many other initiatives) to the promotion of democracy, equity and cultural richness in those contexts (Carr and Kemmis 1986, 2009; Cascante and Braga 1994; López and Lacueva 2007b; McKernan 1996).

As for the ethical concerns, I tried to give priority to my students' learning process when carrying out my research project, avoiding subordinating my students' learning to my research. This was my regular classroom and what happened there was an integral teaching activity in the first place. Students knew I was researching our work, and several expressed this was a good example for them. They consented to be recorded in audio and video, albeit some did it with certain reservations, since they were not use to it and/or were worried about the future diffusion of these documents, which —I have to remark— were only used for my own analysis. It is to be noted that, in the evaluation of the course, some of the students expressed that observing my research activity was a stimulus for their own development in that sense (I have seen this point highlighted also in Dinkelman 2003).

The context of the action research project

The study was conducted in the two sections of a 'Natural Science and Health Education Teaching Methodology' course from the Preschool and First-Stage Elementary Teaching Education program offered by the School of Education of the public university where I work. It is an almost three-hundred-year-old university with around 70,000 students, located in a metropolitan center.

The course that served as framework for my study belongs to the fourth year of a five-year program and included one 90-minute session each week for a whole academic year, which makes a total of 30 sessions. There were two sections during that academic year, both of which were subject of the study. The data were gathered in section A during the first half of the year and in section B during the second half for practical reasons and with the intention of getting more varied data. The anonymity of the participating students has been insured for the purposes of this research study by using pseudonyms instead of actual names. All the quotations have been translated from their original Spanish version.

One main constraint in the curriculum is that there are no courses of scientific and/or technological contents, which means that the only link to the science and technology (S&T) world is the Teaching Methodology course concerned.

Design of action

Based on several general objectives, I divided the course into seven types of activities (See Table 2), which we developed in an overlapping manner throughout the academic year. The course objectives were:

1. Reflecting on the importance of Natural Science and Health Education teaching in the first grades of elementary education.

2. Analyzing pedagogical-didactic proposals for the teaching in this area.
3. Planning, developing and assessing pedagogical-didactic practices reflectively considered beneficial to the children education and linked to the area in question.
4. Selecting, producing and using the needed resources for the planned pedagogical-didactic practices.
5. Taking the first steps in pedagogical-didactic research, basically within the approach of action-research.

The design does not seek that students apply one or the other theory presented by me, but that they develop their own theoretical conceptions and move forward in their enactment of positive practices based on: their university and non-university previous knowledge, their previous experiences as students and student teachers, the readings and discussions we carry out in class about different theoretical and theoretical-practical stances, the concomitant experiences gained in the professional practice, the application of certain pedagogical practices, the simulation ‘like at school’ of a complex practice (learning project). When presenting the results, I will briefly describe each of the activities and justify them from the perspective of theory-practice integration.

(Table 2 here)

Results: Trying to bridge the gap between theory and practice

The name itself of our science education course (‘Natural Science and Health Education Teaching Methodology’) framed within the tradition of the ‘methods’ courses with their prescriptive and nontheoretical character, and its location in a fragmented curriculum with few connections between its components, suggest that the trend will be the enlargement of the split between theory and practice and the reduction of the latter to the application of a series of recipes. On the other hand, the course —by its very existence— emerges as a setting for theory-practice integration, in which it is possible to work on the development of teaching capabilities in the area of Science and Technology Education in parallel with a considerably long professional practice of two days a week for six months. It is also worth mentioning that during that same curriculum year, the student teachers attend another two Methodology courses (in the areas of Social Sciences and Mathematics).

The practice of ‘as-in-the-school’ teacher practice

As part of the design for change, I gave my students the opportunity of practicing in our course some activities which I deem important in S&T teaching at the elementary level. In this way they could ‘rehearse’ them before their professional practice, or at least learn to perform them even if they were not able to apply them in their practice. We have to remember that they were not ‘real’ teachers but student teachers in someone else’s classroom: they were not completely free to develop there any activity of their choosing.

So in our class we did not merely analyze how the S&T class sessions in the first grades of elementary education should be developed, but I offered the students the opportunity to really carry out some suggested teaching activities and to reflect on them: to really enact a practice, even if not with children but with peer teacher students, allows to learn about the

complexities of practice by the enactment itself; and to reflect about practice offers opportunities to elaborate new ideas about what was done and to use in new ways old ideas already known. This was the case of the *resource selection (book, web page, video)*, the *piece of news of the day* brought by the students in turns, the *experimentation with instruments and kits* and the *search, testing and presentation of short science and technology experiences* that could then be proposed to the children. I consider that these activities should be consciously carried out by any good teacher as part of his/her work, if s/he wants to enrich everyday his/her repertoire of pedagogical possibilities. Besides, these are activities that help the teacher to progressively learn more about science and technology.

With respect to the *resource selection*, the cultural tools, such as books, web pages, videos or S&T kits widely contribute to develop and make more complex the so-called higher psychological processes. This has been highlighted by the sociocultural historical approach that emerged from the research studies of Soviet psychologist Lev Vygotski in the first decades of the twentieth century. Throughout human history, the use of different tools has made possible new forms to study reality in greater depth, to record information and communicate different types of knowledge. And these new action forms have expanded our knowledge and have promoted the social and individual development of reflexivity, criticism and creativity (Del Río and Álvarez 2002). It is important that both the teacher and the children have a wide range of cultural artifacts available and that they use them everyday at school. Besides, the teacher mind cannot embrace all knowledge, so the class gains when we take advantage of the distributed nature of knowledge and complement that of the teacher with the one incorporated in resources as mentioned (Putnam and Borko 1997). This activity was aimed at making the student teachers search and use some cultural tools as an example of positive teaching action.

The students devoted time to selecting the resources and their presentations in class allowed us to know of many good books, web pages and videos or TV programs. Reflection was achieved with this activity: Based on some guiding questions I had prepared, the students did not just describe, but they also expressed their opinions about the value of the resource when working with children at school. In most of the cases, the quality of the oral presentation was better than that of the written critical reflection —the latter tended to be more distant and succinct.

This is an encyclopedia from editorial L., addressed mainly to children. Its language makes it pretty enjoyable and easy to understand. It has... It has many, many illustrations... The... all of the topics show plenty of colors. I mean... There are five volumes and each volume addresses a different theme. For example, this one is about the Universe and planet Earth. (...) This... each topic... for each topic there is a words' chest. It is for the children to maybe better understand the text... if there are words unknown to them. There is also a yellow triangle which alerts about any danger in relation with the topic addressed. For example... here... this... (showing the book)... When referring to the Sun, our star, there is a triangle where it says 'Never look directly to the Sun, as the light may hurt your eyes...' (...) There are also... when talking about some topics, there are also poems, stories for instance, here it says (the student reads a short story about the origin of constellations). So there are poems and stories and fables about the many different topics, so as to

facilitate the children's reading, and I think the encyclopedia is very complete... and for us it is very, very interesting (...) there are... it has a lot of activities for the children to do (the student gives an example).

Delmira. Audio transcript. Class session n° 12, pp. 7-8.

In this example, Delmira goes from the general to the particular, in a way that –especially from a transcript and without the visual input- may look rather disorganized. But she highlights several relevant features of the book, and stresses their usefulness to teachers.

The majority of the students seemed to have selected the resource carefully and showed interest when making their presentations, even though there were some cases in which the students just expressed brief and stereotyped opinions. In the questionnaire they filled out at the end of the course, several participants highlighted the value of these activities in their preparation as teachers, stating that they had learned to consider other resources when planning and to differentiate more easily between good and bad quality resources, while they also got to know useful concrete examples.

In the case of the *search, testing and presentation of short science and technology experiences*, either in groups or individually, the students had to find, practice and present in class a 'science' and a 'technology' activity that could be carried out at school. In the school context, these activities could be conducted separately or as part of educational units or research projects, giving the possibility that they be suggested by the teacher or by the children after they had consulted different sources. For time reasons, in our case the activities could not be carried out with the participation of all of us in class. Each team or student making the presentation introduced it to the rest of the students with explanations.

All of the activities presented fulfilled the requisite of being of experiential nature, allowing for direct contact with phenomena or materials, and resulting to be appropriate for elementary education. Only a few of them were too simple, but they could still be useful if combined with other activities. Among the options that were presented we can mention homemade compass, rainbow making, chromatography, traffic light with circuit, elevator with fixed pulley, etcetera. After making the demonstrations before their fellow students, most of the participants said something about the feasibility of carrying out the activity in the classroom with the children and about the use that the teacher could make of it. Some people handed out additional material with information about the activity and further literature references. From all the types of activities developed in the course, these two were the ones that the students considered the most valuable in our final survey.

Aminta made a rainbow. She brought a big towel to darken a corner of our classroom. She fixed a mirror to an aluminum tray with plasticine and filled the tray with water. We could see the rainbow (...) although it was rather faint. She talked about light refraction and gave us a handout, with a bibliography of three web pages. We turn off the lights to see the experience. There was interest in the student teachers, although I think we expected something more spectacular.

My diary. Class session n° 11, p. 5.

Norma and Manuela brought a magnetic crane. It is well done, with its little wheels, it turns and can be moved with certain flexibility to catch objects. They try it with keys, clips, and even bigger objects like a pocket stapler. They built it by putting a magnet on its tip, but they explain that it can also be made with batteries, only you would

need big 6 volt batteries and they could not find them. (...) An electric current that passes through a wound wire creates a magnetic field (I say this in unison with Manuela). (...) Manuela explains that this kind of crane is used to move scrap metal pieces.

My diary. Class session n° 21, p. 4.

Two non-consecutive sessions were devoted to the *examination of some of the instruments and kits of our S&T classroom*, among which we can mention the 20X-magnification school microscope, several simple scales, sets of graduated cylinders, beaker sets, alcohol burners, etcetera. The students formed small groups and worked on a rota system going from one station to the other, in which they found the different types of resources and some activity suggestions. In previous academic years, the instruction had simply been to examine the instruments, but this year I asked them to choose and carry out an activity in each of the stations, which they would have to present to their fellow students later on. This instruction aroused more interest and allowed for a more focused work. After they had changed stations for the first time, I told them that it was no longer necessary to present their activity to the rest of the class, which made people become less interested in the task. However, both sessions were successful; some of the students even said that they wanted to make photocopies of the activity suggestions, and two students asked where the instruments and kits had been acquired. Our only male student, Antonio, asked permission to bring three of the microscopes to the classroom where he was making his professional teaching practice, reporting considerable interest from his students after carrying out the activity. Antonio's idea is a good one, and we could spread this practice by encouraging the student teachers to try the use of these kits with their own schoolchildren within the framework of their professional practice, perhaps in small groups that take turns while the rest conducts any other activity with the teacher of the class.

I think our classroom should be equipped with more and more varied instruments and kits to diversify our student teachers' scientific work possibilities in their future classrooms. To achieve this, we would need to mobilize the support of the institution's authorities. I would also suggest including two more sessions of this kind in our course. In the final questionnaire, three students agreed on these remarks, and two interviewees also made special mention of this.

As of *the science or technology weekly piece of news*, each week, one student would bring and present to the class one or two pieces of news from the science, technology or health field, to be then hanged on the board. This activity was aimed at familiarizing the future teachers with the reading of the newspaper, especially the science and technology sections, for a teacher who reads the newspaper is continuously updated on the latest developments and acquires new knowledge that s/he can deepen later on by other means. At the same time, this activity served as a model for their future teaching, since it could be reproduced in a simpler form in an elementary school classroom, especially in the latest grades. It is important to remember that there are some newspapers that even devote pages to the children and that some magazines and web pages have news aimed at them as well. The novel issues presented in the press can give rise to school projects different from what it is usually done and that might have more social relevance.

Most of the students consulted newspapers, but also Sunday supplements, magazines found in doctor offices, popular science magazines and electronic publications. Although there

were news about science and technology, most of them dwelled on health-related topics. Some examples are Water in Mars, plants in danger of extinction, tattoos and their risks, laparoscopy surgery, children's obesity increase.

A tapir was born at the Mérida zoo. (Comments of interest of several students, 'Oh, yeah', 'I saw it', 'On Tuesday'...). A tapir. (...) Actually, these animals are at risk of extinction, there are only four tapirs (I: 'Four tapir species'). Yes, four tapir species. (...) They have the animal indoors, away from the mother, because they don't want... because, as it is raining so much, they don't want the tapir to... to get sick, so this is why they are protecting him. Besides, tapirs are born with stripes to protect themselves from leopards, lions... (Kirsten shows photograph from the piece of news). (One student: Oooohhh –tenderly) because it works as a camouflage when they are born. (Second student: 'Let me see, let me see'. Third student: 'So he is not brown like adult tapirs?'). Exactly. (Fourth student: 'He looks like a fawn'). Yes. And since they are animals at risk of extinction, well... marvelous. Okay, that is all. (Applause).

Kirsten. Audio transcript. Class session n° 21, p. 9.

About 45% of the students used their own words in their presentations, showing true reading comprehension. Over half of the group had some problems in comprehending and thoroughly transmitting the information they had read, due to their lack of knowledge about the specific topics and of further inquiry beyond the piece of news. Nevertheless, the fact that they did the research, read the material and presented it was already something positive. There were some students who brought additional pieces of news to be hanged on the board.

In future experiences, it would be useful to recommend the students to work more on the pieces of news before presenting them to the group: read them again, consult other knowledge sources to clarify the information, and try to summarize the content with their own words instead of simply repeating it. These recommendations are based on the procedures followed by the students who achieved the best results.

The 'at our level' students' practice

I decided to include in our course the development of a 'like at school' project, where my students would not play the role of teachers, as in the previous activities, but the role of students. The rationale of this activity was to contribute to the student teachers' preparation by orienting them in the fulfillment of the processes involved in a small-scale school research project focused on S&T, so that they would be able to better guide their own students in the future in such an activity within the classroom. I do not consider advisable to make too many of these 'like at school' activities, because the student teachers need to go beyond what the children usually do, and make further educational reflections about the contents and activities covered (Putnam and Borko 1997). Yet, the prudent use of this classroom processes simulation is a fruitful option, especially when it is complemented with the reflection on what has been done.

Since 1998, project work is a regular part of the national curriculum at the elementary school level in Venezuela; however, this powerful pedagogical perspective has faced difficulties in its implementation, both for the Ministry of Education in providing feasible

guidelines in accord to the flexible and investigative nature of the approach, and for the teachers in guiding their students in the development of real inquiry projects.

The participants in my classroom thought about possible research topics, presented their proposals and then voted for the one of their preference —the selected topics being ‘The Universe’ and ‘The Human Body’ in the respective sections. It became clear that some of the students proposed topics not because they were particularly interested in them, but because they appeared in the official curricula. They thought this way they would better prepare themselves for their professional practice, which I think is valid in the case of student teachers. It was quite easy to derive sub-topics from each general topic, so that we would not have the whole class researching on the same aspects. Each group soon presented their project design, which included both the documentary research and empirical inquiry activities, as had been stressed, even though they did not focus so much in the latter. Yet, when it came to the development of what they had planned, very few groups did comply with the empirical inquiry they had presented in their project designs: Almost all of them just worked on the documentary research, as is usually the case with children at school.

The students did make a particular effort in communicating what they had researched: They used oral presentations, demonstrations, small experiments, sample items, dramatizations, story reading, ‘TV news broadcast’, boards, PowerPoint presentations, photographs, problems or exercises for their fellow students, ‘quiz contests’, play dough models, sheets, blood pressure taking, etcetera. The ‘Stars II’ group constructed a model of the star life cycle with balloons of different colors and sizes. In the other section, the ‘Digestive System’ group brought to class a giant digestive system made of EPS foam and plastic, and a volunteer circulated inside it as if she were an *arepa* (corn-made native bread) being eaten, while the rest of the group members explained the processes and some others helped with the dramatization.

In parallel to the development of the project, we conducted additional activities like the ones I think should always accompany genuine school projects, namely visits, talking to experts, paper-and-pencil exercises, reading and commentary on an episode of science history related to the topic, links to the art world (painting, poetry, stories...). I also brought to the classroom some reports of project-based teaching experiences of teachers of our country, as well as experiences I had directly observed. A few students also narrated experiences they knew about.

At the end of the process, we had a class session to recount and reflect on this activity. At that moment, so as in the final survey of the course and in the interviews made to some participants, the simulation of ‘a project like at school’ was considered to be valuable by the students, who deemed it as one of the best activities of the course for its usefulness and enjoyable nature. I believe that this initiative should continue to be put into practice, but trying to strongly reinforce its research dimension in the future.

(...) So it’s pretty cool, because it’s something practical. We don’t learn like ‘This is the way to do a project’ or like you have to include four questions... No. But very detailed... and, well, we did it.

Génesis. Audio transcript. Class session n° 28, p. 11.

Reflective teaching practice

The activity that better served theory-practice integration in our course was the one called *Science in my class*, in which it was possible to establish a direct link with the parallel professional practice my students were having in elementary schools, and explicitly interact with it since its beginning and in a reflective manner. This was a prolonged practice of two days a week for almost six months in an assigned classroom at a local school. It is important to point out that a university professor was in charge of supervising this practice, so as its assignments, teaching plans and final report. I did not mean to interfere, but to establish a positive interrelation between this professional practice going on at schools and the parallel science methods course I was in charge of at the university.

I asked the students to hand in their planning for the S&T area in order to examine it and, then, a report giving account of the teaching experience in the classroom where they had done their teaching practice. I prepared a guide that I gave to the students, in which I proposed a simple and flexible planning model and suggested that the final critical reflection included positive aspects, achievements, deficiencies, problems, obstacles, any surprises that might have emerged, anything they have particularly learned from their experience, and suggestions they would like to make, among other aspects. I encouraged them to keep a field diary during their practice and to gather samples of their students' pieces of work (in photocopies), so that they could have a better input when writing their reports.

Subsequently, I arranged a series of brief sessions in our class to let each student share his/her teaching experience with his/her fellow students. In these oral presentations, most of the students put an emphasis on the description of their activities and not so much on the necessary critical reflection. However, in their written reports reflection played a more important role, even though it still lacked systematicity and depth. All in all, presenting to others what they had done during their teaching practice already demanded putting some distance and somehow conceptualizing their ideas. As Ax, Ponte, and Brouwer (2008, 57) say, 'shared knowledge is necessarily abstracted knowledge which is open to debate'. Many students described their teaching experience in a very comprehensive way, highlighting important aspects that they illustrated with educational material and the pupils' pieces of work, as I had suggested in the guide.

Out of the 28 reports gathered, 4 gave account of very traditional experiences, 8 showed some progress with more formative activities (dramatizations, comparative charts, models, etc.) and 16 presented experiences of more direct contact with natural phenomena, living beings or technological products (experiments, observations, small-scale constructions or models, museum or planetarium visits, etc.).

In their reflections, the students highlighted positive and negative aspects, even though in the latter case they mostly referred to external obstacles rather than to their own deficiencies. They not only mentioned aspects related to the classroom, but also other elements that had to do with the whole school, and even some aspects related to the national school system as a whole. They also established comparisons with the preschool level, which they already knew well as it had been part of their preparation program. In Tables 3 and 4, I present some evidence of my students' statements. Some reports presented thorough descriptions and in-depth analysis, while others were brief and contained very general information. The reports ranged between 2.5 to 20 pages, most of them being of 7 to 9 pages. I agree with Aubusson, Griffin, and Steele (2010, 201) when they say that

‘reflection is critical to successful pre-service teacher learning, but it is hard to teach and difficult for students to conceptualize’: In their self-study with collaborators, it is possible to appreciate the stages of an intervention in a teacher educator’s own class to promote better reflection, with promising results and the proposal of combining both contextual and conceptual anchors in the reflective process in the future.

(Table 3 here)

(Table 4 here)

Emsheimer and Ljunggren De Silva (2011, 147) express the need for student teachers to have ‘a creative way of dealing with experiences –not only talking about them but also trying to understand experiences in the light of theories’. In this interrelated manner, they can understand both theories and experiences at a deeper level. But the authors acknowledge that it is not common to find this advanced form of reflection among student teachers. I will come to this point again later. In my course, explicit references to particular theories or authors were very scarce in student teachers’ reports.

I intentionally selected a group of 18 teaching practice reports that would show for varied results, with the objective of carrying out a more detailed document study (Lacueva 2010b). The results show that the *four prevailing topics addressed by the researched student teachers* were: importance of affectivity in teaching, rejection of traditional routines, concern about discipline, and positive appraisal of the children. The student teachers believe that interest is necessary for learning and that it should be fostered in class; they also consider important that the children enjoy the school experience.

Another positive aspect was the interest shown by the children towards the subject.

Reimy. Teaching Practice Report, p. 5.

At the same time, they think that the traditional copy and dictation routines performed by the pupils sitting in isolation are negative.

We teachers should embark on the adventure of breaking classroom monotony and going beyond traditional education, and start setting real challenges to our students against the background of some topic of total interest and pleasure for the children. If we combine all this with an optimal learning environment, a facilitating role on the part of the teacher, and the needed activities, experiences and resources, our children could begin to nicely surprise us with much more complex and meaningful learning than the one we usually see when we work with our restricted and closed plans.

Norma. Teaching Practice Report, p. 12.

They also highlight positive qualities of the children, stating that they are curious, that they pose good questions, that they are creative and make beautiful pieces of work, that they are good observers, bring material to class, show interest and/or know things, among other qualities.

I was surprised to see how motivated they were when doing their research and how interested they were in clarifying doubts and posing questions about the unknown.

Fulvia. Teaching Practice Report, p. 8.

No student teacher referred to negative qualities of their pupils, except for the behavior problems that make up the other main topic of the reports. Most of the student teachers are concerned about the lack of discipline that commonly prevails in our public schools and strive to achieve what is known in the teacher slang as ‘group control’.

The *Science in my class* activity gave the students, in a certain way, the possibility to experiment a whole action-research cycle—from the observation and planning to the implementation of their plans, the monitoring and the subsequent reflection on the process. However, it is necessary to strengthen the research dimension of the professional practice. In this sense, we need to put an emphasis on the conception of planning as the preparation of enriching experiences for the children. We also need to focus more on the monitoring of classroom processes, with careful records and systematic gathering of produced documents, and the professional practice report should be presented as the product of a critical thorough and supported reflection (although time restrictions and academic obligations of students might be an obstacle for this aim). In the last section of this paper, I make further suggestions in this respect.

The practice of reflecting on theory

Throughout the academic year, my students had to individually write and hand in three reflective compositions on educational matters, which would be then discussed in plenary. I gave them a list of specific readings (some obligatory and some additional ones) for each of the topics, as well as a few questions to guide their writing process. The topics addressed were the reasons for S&T at school, ‘everyday’ ideas vs. scientific ideas, project-based and inquiry learning, planning, evaluation, and class session structuring.

The guiding questions I gave to the students were aimed at encouraging them to compare what the different authors said about the same issue, summarizing what they had read through diagrams, mind maps and other methods, expressing their own opinions and proposals, commenting on ideas that had aroused their interest, pointing at what they agreed and disagreed about, establishing links between what they had read and their own experiences as students and student teachers, and giving possible examples of certain pedagogical strategies, among other things. The basic readings for the three reflection essays were, as such, theoretical-practical readings dwelling on the topic of an inquiry oriented S&T education at school.

Writing these three essays was the less successful activity of the academic year in terms of the students’ performance. Even though the majority of the students handed in the assignments, 14 people (almost one third of the two sections total) did not hand in one of them, and in some cases even two of them. From the total of 43 students, 8 had a high level of achievement in these reflective essays, 18 had a moderate performance and 17 remained unsatisfactory, even though most of them managed to get minimum grades to pass these assignments. It is not my intention to make much emphasis on the indicative value of grades (which I gave because it was a requisite of the institution), but I have to acknowledge that presenting their own ideas about pedagogical issues in writing posed difficulties to the students. Why was this so? Some answers in need of further study would

be: lack of practice with this kind of activity, the intrinsic difficulty of this task, and the need to better connect the readings and essays with the experience of these students-teachers at schools.

The students' texts reflected problems, such as more or less direct copying from the assigned readings, skipping some of the questions, succinct answering, answering with superficial stereotyped remarks, jumping from one idea to the other in the same paragraph with little coherence, and avoiding the question itself by answering with general statements that could have been expressed by someone who did not get to read the material. There were also writing problems.

When I detected the deficiencies of the first essay, I made a brief list of suggestions for 'optimal results when writing critical essays', in which I recommended, for example, reading the assigned material at least twice, revising the rough draft, avoiding sticking to the trite remarks commonly heard in the field of Pedagogy, checking the spelling and the composition technique. These suggestions were commented in class, but, in general terms, I did not see any significant improvement after giving them to the students —there was progress in the second essay, but it was not maintained in the third one. Progress in this field requires time and opportunities in more than one course. In some cases, they would demand more focused guidance and practice, like for instance in a workshop specifically aimed at developing writing skills.

Nevertheless, I have to say that most of the students handed in their reflective essays and tried — more or less successfully— to structure their ideas around the pedagogical issues that had been established, in a 'dialogue' with the authors of the recommended readings. I received essays of 3.5 pages and others of 10 and even 18 pages. Important ideas were brought up, even though the students did not sufficiently elaborate on them. Evidence of these considerations can be appreciated in Table 5, where I present examples of the students' remarks from the first reflective essay; they are taken from essays that were graded high, medium and low.

(Table 5 here)

The three reflective essays were discussed in class. In most of the cases, the oral accounts flowed more easily than the written ones and included more varied elements: comments on what the students had read throughout the course and, in other courses, accounts of the experiences with children or teachers outside and inside the pre-school institutions, science-society relationships, educational reflections, supported opinions, among others. In one of the sections, the students' participation was a little bit more limited and succinct, while in the other section the students participated in more occasions with longer and more complex remarks. I elaborated on some of the students' remarks, trying to incorporate new ideas, offer different points of view and draw their attention to certain situations. Within the framework of the whole reflection on educational issues, I also held some brief oral presentations in class. I think lectures should not be the prevailing activity, but their presence is necessary.

The three theoretical reflection essays based on the readings was the activity that the students considered less valuable, although 90% of the class still considered it to be in one

of the top two categories in a scale of five. There were students who highlighted the importance of this kind of work for their professional development, while others thought it was too much effort. And there were also students who considered that the course should focus even more on the theory and its integration with practice.

In the theoretical work, it was very long (sic) (...) It is good to make reflections but not so many for each question; it is better to make just a general one.

Lérida. Self-evaluation I, p. 1.

(...) How to squeeze the very last drop out of each idea, not just present them but squeeze them as much as possible, to get the most... to separate each one of the ideas I had in my mind and try to express them in a way that nothing was left to be inferred but... but to say what I actually wanted to say, right? I think that was one of the most complex issues in the course.

Alicia. Transcript of the interview to Wanda and Alicia, pp. 3-4.

In her answer, Alicia highlights one of the problems with my students' theoretical reflections: my student teachers would often express their ideas about a complex issue in one or two short statements without further elaboration, assuming the reader could understand all what was behind their succinct expression.

Some changes in the course could help the students make better use and enjoy more the reading of theoretical and theoretical-practical material, so as the reflection and discussion about it. For instance, more texts written by national or regional authors should be included in so far as possible, for the students would be able to establish more links with their own lives and the readings could be more accessible and relevant to them. Another recommendation would be to revise the suggestions made to achieve 'optimal results when writing critical essays' and keep on using them, since success in this area certainly requires time. I also think that the guiding questions are useful, as they help students to establish links with previous and current experiences, inciting them to compare, evaluate and generate own ideas. Yet, we should also demand from the students that they hand in a draft at least of their first essay, so that they can receive feedback before they write the definitive version.

In their research in Sweden, Emsheimer and Ljunggren De Silva (2011) found out that many student teachers asked for opportunities to discuss and compare different concepts in class, so as for teacher educators to relate theories to practical examples in order to enhance understanding. The authors tend to agree with these proposals as I myself do. In fact, I tried to follow a similar line of action in my course. Yet, more is still needed to achieve success. The results were not good enough, although without the discussions and the examples they would probably have been worse. The same authors emphasize the need for gradualness in theory-practice interrelation throughout the years of pre-service teacher education.

No 'happy ending', but a step in a long way

My initial goal in the work I have presented was to design and develop a university course that would be more appropriate and relevant for the education of future elementary teachers in the field of science and technology education. Among the main characteristics of the course design was the interrelation of theory and practice. I strived to contribute to the preparation of teachers who want and try to develop fruitful practices and who want and try to theorize about them —teachers who read about pedagogy, who take part on debate, who

take a stand on pedagogical and socio-educational issues, who propose ideas, and who are able to put into practice at least some of their proposals, for the benefit of their students. Certainly, no single course can attain these objectives, but the effort can help student teachers to progress in this direction, while also pointing out possibilities and needs.

My students participated in all the designed activities of this action research project and on this basis they produced written compositions, project designs, oral presentations, debate participations, educational material, among others. In the seven types of activities developed (and in the three course self-assessments) I found theoretical reflection, but with limitations: The trend was towards short texts with succinct phrases. The compositions that the students had to write with their own opinions about the assigned readings constituted the activity that my students considered the least valuable —32% did not even hand in at least one of the three essays. In the *Science in my class* reports, description prevailed over reflection, even though the latter was still present as demonstrated by the examples of Tables 3 and 4.

Regarding the fulfillment of the more ‘practical’ activities, it was not simply a matter of conducting a low-level action or of following a mechanical routine, but it demanded from my students reflective participation throughout all of the activities: in choosing them, developing them, presenting them to their fellow students, and evaluating them in the three self-assessments of the year and in the survey conducted at the end of the course. The results show a certain integration of the professional practice with the university teaching context, even though the number of innovative activities in the area of S&T (advocated in our university course) that were carried out with the children in the schools is still modest, as the traditional routines play an important role compared to the university appeal for innovation.

As for supported teacher research, there were some attempts in the cycle that finished with the *Science in my class* professional practice report, but more systematicity is desirable. These efforts need to be improved through more coordination and integration of the different university courses and of the latter with the parallel professional practice, looking forward to higher research demands. In our course, there was also an attempt to develop a research project of a different kind: a learning project similar to the ones that are desirable at school and dwelling on S&T topics. This project involved documentary research and the efforts to present it in a ‘creative’ way, but it included scarce empirical inquiry.

The obtained evidence reveals progress in the desirable ‘analysis of practice through theory and theory through practice’ (Gutiérrez and Vossoughi 2010, 113) —a progress that can be further improved by developing new alternatives like the ones I present below.

Learning from the achievements: new possibilities for the future

Theory-practice integration could be reinforced if the experiences lived in a course like the one in question could be further integrated among each other, thereby making them more meaningful. As one of our students suggested, several scientific topics from the school syllabuses could be planned by all together, in groups, consulting resources such as books, web pages and videos, searching and trying out formative and dynamic school activities, and deepening the student teachers’ S&T knowledge. Then, each group could present to the rest of the class some of the activities and resources, while the planning work would remain as an input everyone could take advantage of when the professional teaching practices

begin. This process of common planning among colleagues is very fruitful and leads towards the desirable establishment of action-research and learning communities among teachers (Nelson et al. 2008; Putnam and Borko 1997).

Other valuable activities that could be incorporated to integrate theory with practice would be, for example, visits to innovative schools, academic conversations with innovative teachers or the presentation of cases in the form of printed and/or multimedia material to be analyzed by the students. Another possibility is that the students prepare short and interesting S&T activities in groups, which could be simultaneously put into practice in classrooms of a partner school as a small science fair for children. This could be carried out before embarking on the professional teaching practice (Mueller and Skamp 2003).

In order to obtain practice reports with deeper reflections, one could try asking the student teachers to include three to five recommendations of action they would give to other teachers. This could help to systematize and critically assess certain features of the lived experiences, promoting a higher abstraction level without the students leaving out the concrete aspects of their experiences — I take this idea from the User Manual proposed by Rodríguez de Fraga for school technology education (Rodríguez de Fraga 1996, 126-127). Another option would be that the students be requested to go beyond the general reflection and choose one or two particularly interesting events to analyze them, which would provide for more in-depth remarks (Allard et al. 2007). Hammerness, Darling-Hammond, and Shulman go further along these lines and propose student teachers to write about a case based on their professional practice experience. This implies a process of writing various drafts, using the theoretical readings for the reflection, and discussing them with the instructor and university peers. According to these authors, ‘students’ successive case drafts demonstrated a development from naïve generalizations to sophisticated, theory-based explanations of the issues at play in their cases’ (2002, 219).

These efforts to improve the critical reflection of the teachers about their own work could also include asking the student teachers to develop in their reports at least one main idea or some of their assertions based on what they had done. Furthermore, all the generated ideas —or a selection of them— could be organized on a table to be then discussed in class —this is what I do in this paper with Tables 3 and 4, which were unfortunately made after the course had finished (see a similar idea in Loughran 2002). It would be convenient to make more emphasis on the fact that the student teachers support their own planning. In this respect, Richardson and Anders (1994) propose fostering the teachers’ reflection and helping transform their beliefs and educational practices by asking them about their ‘practical arguments’: the reasoning for their actions. These arguments could be linked to more abstract pedagogical principles. This way, the theory would be —as Northfield suggests— ‘an outcome of experience rather than a set of ideas to be applied in unique classroom settings’ (1998, 698).

I also want to point out that we need to intertwine the analytical aspects with the synthetic or gestalt aspects if we want to reach the deepest conceptional level: Different authors recommend teachers to appeal to drawings, photographs, metaphors, parables, and mental images as forms of expression, reflection and reflection on the reflection (Bullough 2010; De Jong, Korthagen, and Wubbels 1998).

A related but different strand worthy of consideration is the one followed by Muñoz, Quintero, and Munévar (2002): The authors worked with student teachers during their professional practice following an action-research approach, but in their case the cycles were short and very dynamic. After each class, the student teachers had to write in their diary, organized in three moments: a descriptive moment, an interpretative-reflective moment and a moment for action-oriented proposals that would lead to positive change; the proposals were tested in subsequent classroom sessions. This strategy is motivating since it puts the description and the reflection to immediate use in the resolution of problems, albeit it precisely has to avoid the illusion and danger of quick fixes to teaching problems. Combining short-term proposals, which the student teachers can put into practice right away, with longer-term ones that will probably not be implemented during the practice but generate reflection and ideas, is probably a good solution.

Going beyond the limits of our course, I believe that the curriculum to which it belongs manages to break with the negative split between theory and practice, but only to a certain extent. Even though the students devote a lot of time to their professional teaching practice, which they make along four years of the program, these practices—at least when I conducted this study—are not sufficiently connected to the theoretical courses. It would be necessary to make transformations in the curriculum as a whole in order to ensure better integration between the practice in the schools and the university courses. The latter could even incorporate small fieldwork projects, conduction of surveys, observation of cases, activities planning, reports and analysis of experiences, among other possibilities. A case that could be considered an example of such an approach can be found in Chant, Heafner, and Bennett (2004): The student teachers attended a seminar while they conducted their professional practice during four semesters. In this time, they wrote various essays about their teaching experience, stated their ‘personal practical theories’ about teaching and learning, confronted them with their planning and implementation in the classroom, and, finally, designed, theoretically supported and developed a brief action-research on some aspect related to their work that they wanted to improve.

Besides, it is important to acknowledge that the sporadic support of isolated schools is not enough: There is the need of a network of partner schools that establish a rich and positive long-term interaction with the university (Darling-Hammond 2006; Lacueva 2009; Sayago 2009; Montecinos and Walker 2010).

Action research studies like the one I have presented help reveal possibilities and obstacles in elementary teacher preparation to reinforce the necessary integration between theory and practice, and encourage reflection and research towards the achievement of a better practice and a better theory production.

Acknowledgments

I want to thank the Council for the Scientific and Humanistic Development of the Central University of Venezuela for partially financing this research study under the Project No. 070055202004.

References

Allard, C.C., P.F. Goldblatt, J.I. Kemball, S.A. Kendrick, K.J. Millen, and D.M. Smith. 2007. “Becoming a Reflective Community of Practice”. *Reflective Practice* 8 (3): 299-314.

- Aubusson, P., J. Griffin, and F. Steele. 2010. "A Design-Based Self-Study of the Development of Student Reflection in Teacher Education". *Studying Teacher Education* 6 (2): 201–216.
- Ax, J., and P. Ponte. 2008. "Praxis: Analysis of Theory and Practice". In *Critiquing Praxis. Conceptual and Empirical Trends in the Teaching Profession*, edited by J. Ax and P. Ponte, 1-18. Rotterdam: Sense.
- Ax, J., P. Ponte, and N. Brouwer. 2008. "Action Research in Initial Teacher Education: An Explorative Study". *Educational Action Research* 16 (1): 55-72.
- Bolívar, R. E., R. Calzacorta, A. Salcedo, and A. Zambrano. 1987. "Trabajo productivo escolar y organización de los alumnos". [Productive School Work and Organization of the Students]. Paper presented at Primer Congreso Pedagógico, Colegio "Presidente Kennedy", Fe y Alegría, Petare, Venezuela, July.
- Bullough, R. V., Jr. 2010. "Parables, Storytelling, and Teacher Education". *Journal of Teacher Education* 61 (1-2): 153-160.
- Carr, W., and S. Kemmis. 1986. *Becoming Critical*. Lewes: Falmer.
- Carr, W., and S. Kemmis. 2009. "Educational Action Research: A Critical Approach". In *The Sage Handbook of Educational Action Research*, edited by S. Noffke and B. Somekh, 74-84. Los Angeles: Sage.
- Cascante, C., and G. Braga. 1994. "Una guía práctica. Tema del mes 'La investigación-acción'". [A Practical Guide. Topic of the Month 'Action Research']. *Cuadernos de Pedagogía*, no. 224: 20-23.
- Chacón C., Ma. A. 2008. "Las estrategias de enseñanza reflexiva en la formación inicial docente". [Strategies for Reflective Teaching in Pre-Service Teacher Preparation]. *Educere* 12 (41): 277-287.
- Chant, R. H., T. L. Heafner, and K. R. Bennett. 2004. "Connecting Personal Theorizing and Action Research in Preservice Teacher Development". *Teacher Education Quarterly* 31 (3): 25-42.
- Ciari, B. 1981. *Nuevas técnicas didácticas*. Barcelona: Reforma de la Escuela. [Orig.: *Le Nuove Tecniche Didattiche*. 1971. Roma: Editori Riuniti. 2nd edition: 2012. Roma: Edizioni dell'Asino].
- Darling-Hammond, L. 2006. "Constructing 21st-century Teacher Education". *Journal of Teacher Education* 57 (3): 300-314.
- De Jong, O., F. Korthagen, and Th. Wubbels. 1998. "Research on Science Teacher Education in Europe: Teacher Thinking and Conceptual Change". In *International Handbook of Science Education*, edited by B. J. Fraser and K. G. Tobin, 681-693. Dordrecht: Kluwer.
- Del Río, P., and A. Álvarez. 2002. "From Activity to Directivity: the Question of Involvement in Education". In *Learning for Life in the 21st Century*, edited by G. Wells and G. Claxton, 59-72. Oxford: Blackwell.

- Díez Navarro, C. (1998). *La oreja verde de la escuela. Trabajo por proyectos y vida cotidiana en la escuela infantil*. [The Green Ear of the School. Project Work and Daily Life at the Kindergarten]. 2nd ed. Madrid: De la Torre. (Reprint 2012).
- Dinkelman, T. 2003. "Self-study in Teacher Education. A Means and Ends Tool for Promoting Reflective Teaching". *Journal of Teacher Education* 54 (1): 6-18.
- Edwards, C., L. Gandini, and G. Forman. 1998. *The Hundred Languages of Children: The Reggio Emilia Approach. Advanced reflections*. 2nd ed. Westport, CT: Ablex.
- Emsheimer, P., and N. Ljunggren De Silva. 2011. "Preservice Teachers' Reflections on Practice in Relation to Theories". In *A Practicum Turn in Teacher Education*, edited by M. Mattsson, T. V. Eilertsen, and D. Rorrison, 147-167. Rotterdam: Sense.
- Feldman, A. 2007. "Validity and Quality in Action Research". *Educational Action Research* 15 (1): 21-32.
- Fenstermacher, G. D. 1994. "The Knower and the Known: the Nature of Knowledge in Research on Teaching". *Review of Research in Education* 20: 3-56.
- Freinet, É. 1977. *Nacimiento de una pedagogía popular*. 2nd ed. Barcelona: Laia. [Orig.: *Naissance d'une Pédagogie Populaire*. 1969. Paris: Maspero].
- Freire, P. 1972. *Pedagogy of the Oppressed*. Translated by M. Bergman Ramos [From the original Portuguese manuscript, 1968]. New York: Herder and Herder.
- Freire, P. 1999a. *Cartas a quien pretende enseñar*. 5th. ed. México, D.F.: Siglo veintiuno. [Orig.: *Profesora Sim; Tia Nô, Cartas a Quem Ousa Ensinar*. 1993. São Paulo: Olho d'agua].
- Freire, P. 1999b. *Pedagogía de la autonomía*. 3rd. ed. México, D. F.: Siglo veintiuno. [Orig.: *Pedagogía de la autonomía. Saberes necessários à prática educativa*. 1996. São Paulo: Paz e Terra].
- Gallas, K. 1995. *Talking their Way into Science*. New York: Teachers College Press.
- Guba, E. G. 1981. "Criteria for Assessing the Trustworthiness of Naturalistic Inquiries". *ERIC/ECTJ Annual* 29 (2): 75-91.
- Gutiérrez, K., and S. Vossoughi. 2010. "Lifting Off the Ground to Return Anew: Mediated Praxis, Transformative Learning, and Social Design Experiments". *Journal of Teacher Education* 61 (1-2): 100-117.
- Hammerness, K., L. Darling-Hammond, and L. Shulman. 2002. "Toward Expert Thinking: How Curriculum Case Writing Prompts the Development of Theory-based Professional Knowledge in Student Teachers". *Teaching Education* 13 (2): 219-243.
- Hussein, J. W. 2006. "Experience-based Reflections on the Potential for Critical Practitioner Inquiry to Transform Teacher Education in Africa". *Journal of Transformative Education* 4 (4): 362-384.
- Kane, R. G. 2002. "How we Teach the Teachers: New Ways of Theorize Practice and Practice Theory". *Prospects* XXXII, no. 3/123.
- Katz, L. G., and S. C. Chard. 2000. *Engaging Children's Minds: The Project Approach*. 2nd ed. Stamford, CT: Ablex.

- Kemmis, S. 1996. Prólogo: La teoría de la práctica educativa. In *Una teoría para la educación. Hacia una investigación educativa crítica*, W. Carr, 17-38. Madrid: Morata. (Orig.: In *For Education. Towards Critical Educational Inquiry*. 1995. Buckingham: Open University Press).
- Kemmis, S. 2010. "What is to Be Done? The Place of Action Research". *Educational Action Research* 18 (4): 417-427.
- Korthagen, F. A. J. 2007. "The Gap Between Research and Practice Revisited". *Educational Research and Evaluation* 13 (3): 303-310.
- Korthagen, F. A. J., and J. P. A. M. Kessels. 1999. "Linking Theory and Practice: Changing the Pedagogy of Teacher Education". *Educational Researcher* 28 (4): 4-17.
- Lacueva, A. 2009a. "Formar docentes para una mejor escuela". [Teacher Formation for a Better School]. In *El reto de la formación docente*, M. Téllez, N. Rodríguez, A. Lacueva, D. Córdova, J. García-Calvo, R. Amaro and Z. Sayago, 65-100. Caracas: Laboratorio Educativo.
- Lacueva, A. 2009b. "Las ciencias naturales y sus tecnologías en la formación del docente integral. Un estudio en la práctica". [The Natural Sciences and its Technologies in Elementary Teachers' Formation]. *Revista Iberoamericana sobre Calidad, Eficacia y Cambio en Educación (REICE)* 7 (3): 99-134. At: <http://www.rinace.net/reice/numeros/arts/vol7num3/art7.pdf>
- Lacueva, A. 2010a. "Formando docentes integrales que quieran y puedan enseñar ciencia y tecnología". [Preparing Elementary Teachers Who Want and Can Teach Science and Technology]. *Revista Electrónica de Enseñanza de las Ciencias* 9 (2): 309-332. At: http://www.saum.uvigo.es/reec/volumenes/volumen9/ART2_Vol9_N2.pdf
- Lacueva, A. 2010b. "Buscando salir de la rutina: Ideas y acciones de practicantes de docencia integral en/sobre sus clases de ciencias naturales". [Trying to Break the Routine: Student Teachers' Ideas and Actions At/About their Natural Science Class]. *Revista de Pedagogía* 31 (88): 61-95. Also at: http://www.scielo.org.ve/scielo.php?script=sci_arttext&pid=S0798-97922010000100004&lng=es&nrm=iso&tlng=es
- Lodi, M. 1980. *Empezar por el niño*. Barcelona: Reforma de la escuela. [Orig.: *Cominciare dal Bambino*. 1977. Einaudi. Torino].
- López, A., and Lacueva, A. 2007. "Proyectos en el aula: Cinco categorías en el análisis de un caso". [Projects in the Classroom: Five Categories in the Analysis of a Case]. *Revista Electrónica Iberoamericana sobre Calidad, Eficacia y Cambio en Educación (REICE)* 5 (1): 78-120. At: <http://www.rinace.net/arts/vol5num1/art5.pdf>
- López, A., and A. Lacueva. 2008. "Projects in a Sixth-grade Classroom: Entering a Bumpy but Promising Road". *Educational Action Research* 16 (2): 163-185.
- Loughran, J. J. 2002. "Effective Reflective Practice. In Search of Meaning in Learning about Teaching". *Journal of Teacher Education* 53 (1): 33-43.
- Manning, M., G. Manning, and R. Long. 1994. *Theme Immersion: Inquiry-Based Curriculum in Elementary and Middle Schools*. Portsmouth, NH: Heinemann.

- McKernan, J. 1996. *Curriculum Action Research*. London: Kogan Page.
- Montecinos, C., and H. Walker. 2010. “La colaboración entre los centros de práctica y las carreras de pedagogía”. [Collaboration between the Centers of Professional Practice and Pedagogy Careers]. *Docencia* no. 42: 65-73.
- Mueller, A., and K. Skamp. 2003. Teacher Candidates Talk. Listen to the Unsteady Beat of Learning to Teach. *Journal of Teacher Education* 54 (5): 428-440.
- Muñoz, J. F., J. Quintero, and R. A. Munévar. 2002. “Experiencias en investigación-acción-reflexión con educadores en proceso de formación”. [There is an English version: “Experiences in Reflective Action Research with Practice Teachers”]. *Revista Electrónica de Investigación Educativa* 4 (1). At: <http://redie.ens.uabc.mx/vol4no1/contents-munevar.html>
- Murillo T., F. J., Academ. coord. 2006. *Modelos innovadores en la formación inicial docente. Estudio de casos de modelos innovadores en la formación docente en América Latina y Europa*. [Innovative Models in Pre-Service Teacher Formation. Case Study of Innovative Models in Teacher Formation in Latin America and Europe]. Santiago de Chile: OREALC–UNESCO. At: <http://unesdoc.unesco.org/images/0014/001465/146544s.pdf>
- Nelson, T. H., D. Slavit, M. Perkins, and T. Hathorn. 2008. “A Culture of Collaborative Inquiry: Learning to Develop and Support Professional Learning Communities”. *Teachers College Record* 110 (6): 1269-1303.
- Northfield, J. 1998. “Teacher Educators and the Practice of Science Teacher Education”. In *International Handbook of Science Education. Part Two*, edited by B. J. Fraser and K. G. Tobin, 695-706. Dordrecht: Kluwer.
- Pearce, Ch. R. 1999. *Nurturing Inquiry. Real Science for the Elementary Classroom*. Portsmouth, NH: Heinemann.
- Perrenoud, Ph. 2001. “La formación de los docentes en el siglo XXI”. [Teacher Formation in the Twenty-First Century]. *Revista de Tecnología Educativa* XIV (3): 503-523. At: http://www.unige.ch/fapse/SSE/teachers/perrenoud/php_main/php_2001/2001_36.html
- Putnam, R. T., and H. Borko. 1997. “Teacher Learning: Implications of New Views of Cognition”. In *International Handbook of Teachers and Teaching*, edited by B. J. Biddle, T. L. Good and I. F. Goodson, 1223-1296. Dordrecht: Kluwer.
- Ramos, J. 1999. “Preguntar, debatir, indagar, compartir, cuestionar, reconsiderar, concluir... para aprender”. [Asking, Debating, Enquiring, Sharing, Questioning, Reconsidering, Drawing conclusions... in Order to Learn]. *Investigación en la Escuela*. 38: 45-64.
- Richardson, V., and P. Anders. 1994. “The Study of Teacher Change”. In *A Theory of Teacher Change and the Practice of Staff Development. A Case in Reading Instruction*, edited by V. Richardson, 159-180. New York: Teachers College Press.
- Rodríguez de Fraga, A. 1996. *Educación tecnológica (Se ofrece). Espacio en el aula (Se busca)*. [Technology Education (Offered). Space in the Classroom (Needed)]. 2nd. ed. Buenos Aires: Aique / ORT Argentina.
- Rodríguez, N. 2009. “Retos de la formación de docentes. El caso de Venezuela”.

[Challenges in Teacher Formation. The Case of Venezuela]. In *El reto de la formación docente*, M. Téllez, N. Rodríguez, A. Lacueva, D. Córdova, J. García-Calvo, R. Amaro, and Z. Sayago, 37-63. Caracas: Laboratorio Educativo.

Rorrison, D. 2011. "Border Crossing in Practicum Research". In *A Practicum Turn in Teacher Education*, edited by M. Mattsson, T. V. Eilertsen, and D. Rorrison, 19-44. Rotterdam: Sense.

Rust, F. O'C. 2009. "Teacher Research and the Problem of Practice". *Teachers College Record* 111 (8): 1882-1893.

Sayago, Z. 2009. "Modelos de colaboración entre universidad y escuelas básicas. Implicaciones en las prácticas profesionales docentes". [Models of Collaboration between University and Elementary Schools. Implications on Teachers' Professional Practice]. In *El Reto de la Formación Docente*, M. Téllez, N. Rodríguez, A. Lacueva, D. Córdova, J. García-Calvo, R. Amaro, and Z. Sayago, 193-221. Caracas: Laboratorio Educativo.

Smith, T., C. Edwards-Groves, and R. B. Kemmis. 2010. "Pedagogy, Education and Praxis". *Pedagogy, Culture & Society* 18 (1): 1-8.

Torres, R. M. 1996. "Formación docente: Clave de la reforma educativa". [Teacher Formation: A Key for Educational Reform]. In *Nuevas formas de enseñar y aprender*, edited by UNESCO-OREALC. Santiago de Chile: Unesco-Orealc. At: <http://www.lpp-uerj.net/olped/documentos/0565.doc>

Whitin, P., and D. J. Whitin. 1997. *Inquiry at the Window. Pursuing the Wonders of Learners*. Portsmouth, NH: Heinemann.

Zeichner, K. M. 1995. "Los profesores como profesionales reflexivos y la democratización de la reforma escolar". [Teachers as Reflective Professionals and Democratization of School Reform]. In *Congreso Internacional de Didáctica. Volver a pensar la educación. Volume II. Prácticas y discursos educativos*, 385-398. Madrid: Morata / Fundación Paideia.

Table 1. Summary of the information gathering procedures

<i>Evidence gathering procedures</i>	<i>Quantity / Duration</i>
Teacher diary	30 sessions (15 each section)
Gathering of teacher's planning notes	Section A: 29 out of 29 Section B: 28 out of 30
Audio recordings	14 whole or partial sessions (18 hours altogether)
Video recordings	4 whole sessions (6 hours altogether)
Gathering of handed out educational material	14 materials (All)

Gathering of individual students' written works	111
Gathering of students' group written pieces of work	11
Gathering of students' self-assessments (three per person in the whole year)	55
Formal group interviews	3 (25-30 minutes each, 2 with 3 students and 1 with 2 students)
Final questionnaire	Handed out to everyone. Answered by 24 people (~56 %).

Table 2. An overview of the activities developed in the course

<i>Activity</i>	<i>Description</i>
The weekly piece of news	Bring to class and comment one or two pieces of news about S&T. (Individual student work and plenary session)
A book, a web page, a video... that is worth knowing	Make an oral and a brief written commentary on one resource of each kind that is useful for the teaching of S&T at school or preschool. (Individual student work and plenary session)
Science activity and technology activity	Present a science and a technology activity in the classroom that can be carried out at school or preschool. (Group or individual work, plenary session)
Two sessions with instruments and kits	In work stations, examine different instruments and kits, and carry out an activity with them that will be then shown to the rest of the class. (Using note cards) (Group work and plenary)
Three essays with reflections on educational practice	Write essays that contain reflections about assigned readings; discuss them in class. (Individual student work and plenary discussion)
Simulation of 'A project like at school'	Participate (at their own level) in a school research project or theme immersion focused on S&T, similar to the ones that can be carried out with schoolchildren. (Plenary and group work, in different stages)
Science in my class	Present oral and written reflections on the S&T class sessions developed in the professional practice carried out in parallel. Previously present the planning to the teacher educator. (Individual student work and plenary session)

Table 3. Some remarks and reflections of the student teachers about their own teaching.

Positive aspects

The pupils

The children learned.

The children enjoyed the activity a lot.

Interest.

Participation.

The children brought material to class that was related to the topic.

The children make tough questions (Why do the planets not crash into each other when they turn? What is cosmic dust?).

The children were very capable, they researched, used the vocabulary, shared their results and showed to be very creative when drawing or constructing models. I was surprised by their cognitive and social development.

I noticed some progress of the children, as they wrote about their thoughts and did not simply give pre-established answers.

The activities

Many times, we are too much concerned whether they are yelling or they stand up... We should pay more attention to the purpose of our activities: What really matters is that they learn and not that they all keep sitting and still.

Working in small groups is essential, because the interaction achieved helps clarify many doubts and make students learn new things and share them.

It is necessary to carry out experimental activities, in which the children can appreciate things in a direct manner.

Giving classes within the framework of a big project generates another kind of knowledge that is more significant to the children and the teacher.

The value of the visits: The teacher learns, the children pose many questions, and new interesting topics come up.

It is of extreme importance to include natural science education from an early age —it stimulates the children's interpretation of natural phenomena, their analytical skills and even their imagination.

The student teacher and his/her performance

It is very important to be well prepared in the area of natural sciences. We lack this.

From the moment I was informed about the project topic, which I like very much, I started to do research: books, drawings, Internet...

I did the evaluation using different procedures (anecdotal records, comparison lists, assessment of pieces of work...)

I believe I managed to keep the children's interest and their desire to learn, which I consider essential for a significant class session.

(Source: Students' written reports on the 'Science in my class' activity).

Table 4. Some remarks and reflections of the student teachers about their own teaching.

Negative aspects

The pupils

The problem that the children do not listen to each other and do not know how to get over their differences and work together (this improved throughout the practice).

Large and difficult group with learning and behavior problems, not allowing for group work.

Too many children in the classroom.

The activities

The projects in this school lie in a folder or hang on the board, but they are not really chosen by the children neither developed in the end.

Copying 'conclusions' from the blackboard takes the children too much time and the point of the class session is missed. I did not ask the children to copy anything, but then, on the next day, I saw that the children had a copy of the topic I had addressed in their notebooks. The teachers say that this way the children have something to study with.

Why do we work better at preschools if it is more difficult? The children choose their own work areas of the day, they participate more in determining their projects, they have differentiated work stations, there is more knowledge integration.

The student teacher and his/her performance

I need to prepare the topics better. When I finished explaining the Water Cycle, one child asked me what caused flashes of lightning and I did not know what to answer at that moment.
I was not aware of the time the children needed to understand certain things.
At the beginning, I underestimated the children's capacities. Throughout the implementation of my plans, I realized that the more they knew, the more they demanded from me, and the more they wanted to know and do.

(Source: Students' written reports on the 'Science in my class' activity).

Table 5. Reasons for S&T education in the first grades of elementary school.

Some answers from my students' first reflective essays

Have a first contact with the scientific world.

Allows to experiment and discover.

Helps the children to better define their ideas or to become aware that things are not as they had imagined.

Knowing their reality to be able to take the first steps in comprehending it in a way that allows for its association with ever more complex ideas that would enable them to create, criticize or modify certain situations related to science and thus generate improvements in their own environment.

Develop the scientific spirit and the adaptation to technological changes.

More integration with the world surrounding us.

Teaching technology so that the children are able to discover and develop skills.

Search for answers or solutions to problems.

Fostering the development of thinking skills.

Arousing curiosity, new interests.

Encourage those with possible vocation for that area.

Get to know nature and appreciate the value of the environment.
