# Science teacher education in Argentina

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In Argentina, as in many other countries of the world, science education has been declared a priority, a degree that acknowledges the role of scientific literacy as a fundamental part of the education of future citizens. Yet, low student performances on national and international science assessments, as well as high rates of secondary student drop-out and measurable inequality amongst schools have shown that there is a profound (and urgent) need of improvement in this terrain. It is precisely within this context that the debate on how to prepare science teachers takes on deeper meaning; that is, by recognizing the key role these future educators play on influencing and fostering student achievement.

This chapter presents an analysis of Argentina's teacher education system and examines its preparation of future secondary science teachers. In order to frame the analysis within the local context, the text begins by briefly describing the structure and current challenges of the educational system in Argentina. Then, it examines in greater depth the teacher education system, focusing on the preparation of science teachers, underlining the system´s strengths while raising questions about the challenges for future improvement.

## A brief look at the Argentine educational system

The Argentine education system is regulated by the National Law of Education, which was enacted in 2006 to abrogate the educational reform initiated in 1993 under the previous Federal Law of Education. Some of the major changes introduced with the 2006

reform were the reorganization of the education system's structure, the extension of compulsory education from 5 years of age to the end of the secondary level, and overall the reform of teacher education. In addition, the law stipulates that the national budget for education must not be below 6% of the country's GDP (National Law of Education, 2006).

The system consists of four levels: preschool, elementary, secondary, and higher education. Children attend preschool from 2 to 5 years of age, with the last two years (K4 and K5) being compulsory. Elementary education is intended for children 6 years of age and older and can last between 6 and 7 years depending on the jurisdiction of the school. Secondary education lasts between 5 and 6 years, resulting in 14 years of compulsory education in total.

Working conditions for teachers in Argentina are very heterogeneous. Factors including assigned workload and teacher salaries vary substantially between provinces. Student–teacher ratios also vary within the country, particularly in rural areas. On average, secondary classes have 28 students (Organization for Economic Development and Cooperation [OECD], 2013).

Regarding workload, at the secondary level in particular, 45.7 % of teachers work 24 hours or less per week, whereas 31.8 % of teachers work between 25 and 48 hours, and 10.4 % work 49 hours or more (DiNIECE, 2006). Iit is highly common for secondary teachers to occupy positions in several schools. It is also worth noting that all of the hours reported above indicate the number of hours spent in front of class. In general, there is no extra paid time for teachers to work on planning, grading student work,attend staff meetings, or engage in professional development. This lack of paid time for other tasks

other than teaching to students is, undoubtely, one of the factors that most severely impacts the chances of improving teaching quality in the country.

Teacher salaries are relatively low, in comparison to other professions. Using a teacher with 10 years of experience as a reference point, in December of 2013, yearly salaries at the secondary level varied between US $5,328 and US $10,536 for a 15-hour weekly workload in the same period, depending on the province (CGECSE, 2014). Salary differences (i.e., additions to the base salary) are based solely on seniority, as well as other factors such as school location. For instance, teachers working in disadvantaged areas are often eligible for extra income.

Concerning the school curriculum, Argentina currently holds a set of National Standards (called Priority Learning Guidelines), which direct the development of curriculum guidelines within each state (Federal Board of Education, 2004). In science, the National Standards endorse scientific literacy as a key learning goal for all students and support inquiry-based pedagogies, such as engaging students in guided investigations of natural phenomena, analyzing data and participating in debates over scientific issues (Ministry of Education, 2007). Based on National Standards, each province designs its specific curriculum.

Improving both education quality and equity is currently an urgent issue in the country. Argentine students have performed poorly on recent national and international examinations, both in science and in other subject areas (DiNIECE, 2010; OECD, 2013b; Sequeira, 2009). These examinations have also shown significant differences in student performance according to their socioeconomic status, reflecting a profoundly inequitable educational system. For instance, Argentina was ranked 59$^{th}$ out of the 65 countries

participating in the Programme for International Student Assessment (PISA) 2012. Argentina's mean score in Science was 406, which was well below the OECD average of 501. Almost 60% of Argentine students showed a science proficiency level of 1 or below (approximately 30% of students were at level 1, while 30% were below level 1).

On the positive side, Argentina has experienced a remarkable expansion in enrollment rates at the secondary level during the last decades (OECD, 2014a). Secondary education coverage improved significantly, increasing at a rate of roughly10% in the last decade (Guadagni Alieto et al., 2014). Currently, about 80% of young people aged between 12 and 17 years attend school at the secondary level. However, despite these increasing numbers, less than 50% of the student population graduates secondary level in a timely manner, (Guadagni Alieto et al., 2014) and there is a persistent inequality amongst provinces in terms of school retention and completion rates. For instance, the annual rate of student drop out at this level reaches 15%, and the repetition rate exceeds 6% (Guadagni Alieto et al., 2014). This deficiency is also reflected in the high levels of youth unemployment, which in 2014 affected 17.7% of the population aged between 18 and 24 (INDEC, 2014). Consequently, various efforts are being undertaken regarding the need to support student learning trajectories and prevent student drop out, with different levels of impact (Jacinto, 2009; Tenti Fanfani, 2009). Iniciatives include providing schools with tutors that oversee student learning in all subject-matter areas or offering extracurricular pedagogical support for students in the particular subject areas that they are failing in.

## A fragmented teacher education system

In order to understand the characteristics of teacher education in Argentina, both for science and other subject matters, it is important to have a brief look at the general structure of the system and its recent reform process. In this section of our analysis, we will focus on the preparation of pre-service teachers.

Since its origins, secondary teacher education in this country depends on two differentiated institutional and organizational contexts: higher education teacher education institutes (*Institutos Superiores de Formación Docente*, in Spanish), which are tertiary institutions (i.e. not university-based), and universities, both managed by the public or private sector.

Initially, in a context in which secondary school was conceived as a more exclusive education track that prepared leading sectors for university, it became "natural" for secondary teachers to be university graduates as well (Perlo, 1998). However, in 1904 the first national teacher education institution for secondary teaching was created in Buenos Aires, giving origin to the binary character of teaching degrees as either tertiary education or university.

One of the distinctive characteristics of the latter is that teacher educators hold a university degree themselves, whereas this is not a mandatory requirement in tertiary education. On the other hand, university teacher education degrees typically offer a deeper and more comprehensive disciplinary preparation and demand students to engage in scientific and educational research experiences, which is one of the major pending challenges in teacher education institutions (regardless recent initiatives to enhance research as part of their pedagogical offer, as we will refer to later).

Such conditions result in distinct educational offers, further accentuated by the

traditionally lacking interaction amongst both subsystems, whether through support, exchange or collaboration experiences (Federal Board of Education, 2007b). The coexistence of both subsystems led to a great diversity in terms of the length of studies, curricular contents and degree accreditation (Davini & Alliaud, 1995), which still persists at present despite the renovated efforts to unify and standaridize teacher education programs throughout the country with the 2006 reform.

The system´s is fragmentation is key to understanding some of the challenges teacher education presents in Argentina. To this regard, we join others who claim the need to prioritize and strengthen of teacher training by gradually making it university-based, as it is in many other countries. However, we also recognize that this is a not an easy or straight forward goal to attain, but demands engaging in profound debates on the purposes of teacher education and a strong commitment to persue both realistic and effective reform policies.

In the first place, this is a challenge that would imply a profound structural change, for traditionally Higher Education Teacher Education Institutes had a predominant role in teacher education. This tendency still continues nowadays: only 17.9% of the practicing secondary teachers hold a university teaching degree (Federal Board of Education, 2007f).

We also think that important questions should be addressed about the transformative potential of moving the teacher education system to a university context and under which conditions. In Vaillant´s (2013) words, “even if teacher education is successfully emplaced at university level, this does not guarantee that the quality of

teacher education will be improved *per se*" (P. 199). In this sense, there is the risk of prioritizing a formal structural change without revisiting the most substantial aspects of teacher education. On the contrary, we agree that improving the quality of teaching and strengthening professional skills (whether at higher education institutes or universities) demands revising key aspects such as the teacher education programs´ contents and pedagogical approaches, enhancing the integration of theory and practice, and reinforcing the articulation with the schools (Perrenoud, 2004). Therefore, the aim should not be the consolidation of the system as such, but how to improve in the preparation of teachers in the country.

Recent efforts have been made to make teacher education more coherent. Without questioning the system´s general structure, but in an attempt to unify and standardize teacher education programs throughout the country through a renovated reform process, in 2006 the National Law of Education Nº26.206 and the creation of the National Institute of Teacher Education (INFD, for its Spanish acronym), were enacted. The INFD´s main goal was to develop initiatives that could combine jurisdictional particularities with a shared national vision to re-establish teacher education as a strategic priority for the improvement of education as a whole.

We believe a positive aspect of this process is the commitment towards the consolidation of the teacher education system in Argentina, unified in terms of training quality and with nationwide validation for every program. However, this overhaul also requires the availability of significant resources and the creation and implementation of necessary support systems, which are not always available, especially in the most disadvantaged provinces of the country.

Since 2007, Teacher Education programs and institutions are to be adjusted to national requirements. Taking national guidelines as a general framework, each province has to elaborate their own curricular documents for each teaching degrees and have it approved by the INFD. Yet, bureaucratic obstacles have emerged, and there are still many programs that have not been assessed or permanently accredited; this on-going process has been fulfilled slower than expected and with different levels of compliance (Cámpoli, 2004).

The recent reform process did not only involve structural changes, but also the revision of teacher education curricula and contents. The Federal Board of Education particularly highlighted the need to evaluate and update teacher education curricula and programs as a key initiative to reinforce knowledge and teaching strategies related to literacy, math and science (Federal Board of Education, 2011c).

These changes respond to a renewed interest in adapting the educational system (and teacher education in particular) to the demands of contemporary knowledge societies, technological advances and socio-political and economic circumstances (Esteve, 2006). The founding principles of education systems, linked to the construction of national identity and citizenship, gave way to an economic thrive which focused on educating competent human resources and a social dimension, related to inclusion and equity goals (Tedesco, 2007).

## What is required to be a Science teacher in Argentina?

In Argentina, there is no formal selection of teacher candidates. Applicants for teacher education programs for both the elementary and secondary levels are not required, neither at universities nor at higher education teacher education institutes, to take academic exams prior to admission. The only conditions are that program candidates must have a secondary degree certification (Law of Higher Education, 1995: art. 7) and, in some jurisdictions, must pass a psychophysical health examination (as in many other degrees). In addition, some jurisdictions or particular institutions may also require their students to attend an introductory course, which is often part of their first year of study.

It is not clear how this lack of early selection impacts the quality of the country´s teachers. It is worth noting, however, that this policy is framed under the tradition of open admission to most higher education institutions (including universities) in the country.

On a positive note, this may constitute an opportunity, given that recruiting teacher candidates is actually a major challenge of the teacher education system in the country, which is facing a qualified teacher shortage in many areas, especially in science and mathematics for the secondary level. Various reasons account for this difficulty, such as the diminished social and material status of the teaching profession (Mezzadra y Veleda, 2014; Ministry of Education, 2008; Tenti Fanfani, 2005; UNESCO, 2012).

Secondary teaching degrees have a minimum workload of 2.600 hours in a total of 4 years (National Law of Education, 2006: art. 75). In science, there are currently 4 main degrees that teachers can obtain: Biology, Chemistry, Physics or Natural Sciences.

Every teacher education program is organized into three different fields of knowledge: General Pedagogical Education, Specific Education (or Content Pedagogical Courses) and Professional Exercise (or Specific Field Experience) (Federal Board of

Education, 2007d: art. 30). Between 25 and 30% of students´ total workload must focus on general education, between 50 and 60% must focus on specific education, and between 15 and 25% must focus on professional exercise.

At the end of their degree, prospective teachers do not have to take any national or state examinations, nor produce a thesis, as a requirement for acquiring their license. Again, further research is needed to assess how this lack of national assessment impacts on the quality of the country´s teachers, although some argue it is indispensable to improve teacher education (Mezzadra & Veleda, 2014; UNESCO, 2012).

This absence of any national assessment can be understood within the context of decades of system decentralization initiated with the 1990s reform, which transferred the authority over the educational system from the national level to each jurisdiction, consequently adding to the system´s fragmentation described above.

Also, it is important to take into account that teacher evaluation has traditionally been a particularly problematic issue in Argentina, as it is deeply rejected by teachers and teacher unions who consider it a threat linked to a market-based conception of education (Perazza & Terigi, 2008; Tenti Fanfani, 2005). At present, only a few provinces implement voluntary teacher assessments for in-service teachers, as an exception rather than the norm (see, for example, the Teacher Assessment Program from the City of Buenos Aires).

Lately, a number of initiatives have been put into place, designed to incorporate national or provincial teacher assessments in teacher training. One, the National Plan for Teacher Education 2012-2015 mentions the need to establish a comprehensive assessment of the teacher education system, in order to identify its strengths and areas for

further improvement. For this purpose, it commends the incorporation of annual assessments for students beginning in the second year of their studies. It is worth underlining that these assessments do not intend to evaluate students, since they do not have direct consequences on their chances of graduation; rather, they assess the educational institutions themselves (Federal Board of Education, 2012b). On a similar note, a draft bill has been recently presented at the Congress to assess student teachers at a national level (Draft Bill 1691/15), but has not been approved yet.

Such initiatives, in spite of not being materialized in practice yet and being the subject of current political debate, show revamping of licensure requirements is an issue on the agenda. However, in order to implement these or other initiatives on teacher assessment, both in the pre-service and the in-service levels, there is still a huge need to establish political consensus on the matter of teacher assessment, which does not seem an easy goal in the short term (Perazza & Terigi, 2008).

## The science teacher education curriculum

Regarding the curriculum, the preparation of science teachers in Argentina is framed under a more comprehensive philosophy of teacher education, which underlines teachers´ role in the construction of a just and democratic society for all. As such, national curricular guidelines for teacher education define teaching as a:

> "Reflexive and critical practice of cultural mediation, characterized by the ability to contextualize teaching interventions that promote student learning and support democratic processes within educative institutions, driven by ideals of justice that guarantee better and more dignified living conditions for all students" (Federal Board of Education, 2007d: 25)

Based on these ideals, teacher education programs promote an integral approach

combining subject-matter knowledge and skills, pedagogy and interdisciplinary strategies. In order to clarify the general structure of the curriculum, an example of the complete program for secondary school Biology teachers for one of the largest provinces of the country is presented in Annex 1. Next, we analyse in more detail the different phases of the curriculum: General Pedagogical Education, Specific Education and Professional Exercise, which we describe in more detail below.

**General Pedagogical Education courses**

General Pedagogical Education refers to the domain of conceptual and interpretative frameworks on general issues related to education, teaching and learning. It is

> "meant to develop a solid humanistic education; the domain of conceptual and interpretative frameworks and value for the analysis and understanding of culture, time and historical context, education, teaching and learning; and the development of professional judgement to act in different socio-cultural contexts" (Federal Board of Education, 2007d: art. 30.1).

National curricular guidelines for teacher education emphasize that the main aim of teaching is to promote student learning in real and diverse contexts. This goal implies that teachers have to position themselves as reflective professionals, developing skills "to analyse their everyday practice and contribute to its continuous improvement, taking into consideration its particular context at social, institutional and classroom levels" (Federal Board of Education, 2007d: 26). Such an analytical and reflective capacity, alongside with other skills and dispositions aimed at offering equal and quality learning opportunities for all students, should be fostered during teacher training, as it is listed in Table 1 below.

**Table 1**

*Abilities involved in teaching according to the National Curricular Frameworks for Teacher Education in Argentina*

Teachers should be able to:

a) Dominate content and update their theoretical frameworks.

b) Adapt, produce and assess curricular content.

c) Recognize the educational purposes involved in teaching contents.

d) Broaden their own cultural horizon beyond the specific contents they have to teach.

e) Identify the students´ learning characteristics and needs as the baseline for their teaching practices.

f) Organize and conduct learning situations taking into account the socio-political, cultural and linguistic contexts they take place in.

g) Develop pedagogical approaches that take into account student diversity based on the firm belief that all students have the ability to learn.

h) Actively involve students in their learning process.

i) Support student learning by identifying their strengths and areas of improvement.

j) Manage time and create a positive classroom environment to enable all students to learn.

k) Enable learning at both collective and individual levels.

l) Make an efficient use of the available resources for teaching.

m) Select and make an appropriate use of ICTs according to the teaching context and purposes.

n) Recognize the contexts´ characteristics and needs at school, family and community levels.

o) Interact with the students´ families to foster their involvement in the educative process.

p) Teamwork with other teachers, develop shared institutional projects and participate in school initiatives.

*Source: Compilation based on the National Curricular Guidelines for Teacher Education (Federal Board of Education, 2007d).*

It becomes evident, then, that teacher training is not only defined as requiring

proficiency in subject-matter content, but that this should be complemented and enriched with other key skill sets to perform successfully as secondary teachers: knowledge on different pedagogical approaches, teaching strategies, national history, political and legal organization, epistemological perspectives; and skills to work as a member of a team, develop student assessment, incorporate ICTs in teaching, amongst many others (Hisse, 2014). All these topics are covered within the General Education courses of the program, and shared by all future teachers independently of their subject matter.

One of the main challenges regarding the field of General Pedagogical Education is that it is often boarded superficially, presented as a mere framework decontextualized from its epistemological grounds, instead of fostering a deep and complex understanding of the educative process (Federal Board of Education, 2007d). Yet, as we will discuss below, it is argued that programs give much emphasis to general pedagogy, with less instruction time devoted to specific preparation for science teaching, which limits teachers´ preparation (Cofré et al, 2015).

**Specific Education courses**

The Specific Education phase of teacher education programs are meant to address the analysis, formulation, and development of knowledge and teaching strategies for the particular level and subject-matter student teachers aim to graduate in (Federal Board of Education, 2007d). It is oriented to build an understanding of the particularities of the subject matter (Biology, Physics or Chemistry, accordingly) teaching at secondary level, as well as its purposes in the education system and society as a whole (Hisse, 2014).

Therefore, Specific Education involves the study of the particular subject-matter content, pedagogical content knowledge (Shulman, 1986), students´ particularities related

to that subject and the main issues related to the given level or modality (Ferrata, 2014). Teacher candidates should not only demonstrate proficiency to dominate the essential subject-matter concepts and procedures, but to implement appropriate teaching strategies to enable learning for each content´s, students' and contexts' characteristics (Hisse, 2014).

National guidelines state three irreducible goals for science learning: *know* science (as a process and as a product), *do* science and *communicate* science (Pogré, 2010: 11). An understanding of science as a social construction and human endeavour is promoted, while a critical look at the nature of science is stated, "questioning distorted ideas on its nature based on inductive, positivist and empirist epistemologies" (Hisse, 2014: 15). It is worth noting, however, that neither inquiry-based pedagogies nor the concept of science practices are explicitly mentioned, as it is the case with other countries´ teacher education programs (see for example NGSS, 2013).

To this regard, guidelines foster an integrated and global approach of science, which combines the understanding of science as a product (a body of knowledge) and as a process (the skills and procedures through which this knowledge is produced). Particularly, several jurisdictional curricular guidelines propose "a historic and epistemological perspective through the incorporation of two specific units that problematize the conception of science and the processes of scientific knowledge production, considering its sociocultural, historic, ethical and political dimensions" (Hisse, 2014: 18). Within each program, 3-4 courses are designated to the history and philosophy of science.

In addition, these guidelines emphasize the need to include experimentation as a

key practice in teacher training, for it is one of the most characteristic features of scientific methodology. It is argued that teachers should implement such an approach in their own science classes for it fosters student motivation and learning: "it is considered that having students design and perform their own experiments at school enables a better understanding of how scientists work to solve problems, which results in a deeper comprehension and reflection on the nature of science and its phenomena" (Hisse, 2009: 111).

Table 2 below enumerates the main knowledge and skills science teachers are expected to dominate regarding science practices.

**Table 5**

*Kew knowledge for science teachers according to the national curricular frameworks*

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|---|
| Science teachers should know: |
| a) The methods of scientific production in the past and in the present. |
| b) The main notions of the core scientific theories. |
| Science teachers should be able to: |
| c) Recognize, propose and find possible solutions for scientific problems. |
| d) Hypothesize. |
| e) Recognize and operate multiple variables. |
| f) Design simple experiments to test hypothesis. |
| g) Propose fieldtrips to test hypothesis. |
| h) Use investigation as a teaching strategy and differentiate it from scientific investigation. |
| i) Use scientific language and foster students to apprehend specific terms. |
| j) Reflect on their conceptions on science in order to promote student learning. |
| k) Select content and elaborate pedagogical proposals to foster significant learning, in accordance to curricular frameworks. |

l) Value and work with particular emphasis on transversal, integrated social and natural science matters such as environmental education, health education and sexual education.

m) Stimulate student motivation through appropriate teaching methods and by fostering the exchange of ideas, creativity, debates, etc.

n) Contextualize scientific problems according to the classroom and students´ characteristics.

o) Write reports.

p) Link scientific issues with the students´ interest and everyday life situations.

q) Plan activities that enable students to understand key scientific concepts.

r) Use pertinent and varied teaching resources (ICTs, books, etc.).

s) Model the performance of science activities in terms of security, scientific rigor and precision.

*Source: Compiled based on Hisse, 2009.*

However, research has shown that this proposed vision of science, which integrates epistemological and historical aspects, as well as the development of science practices as a learning goal for future teachers, still presents profound challenges for teacher educators, whom in many cases have not been prepared themselves in such vision or practices (Cofré et al., 2015). Very few teacher educators have any personal experience in scientific or educational research, which also hinders their ability to engage with innovative teaching strategies or introduce students to more realistic perspectives on the nature of science and scientific practices (Adúriz-Bravo, 2009).

This is particularly problematic, since science education reforms worldwide suggest that students´ understanding of the nature of science is a main educational outcome (Lederman et al., 2014), which, in turn, implies that understanding the nature of science should be a key aspect in teacher education.

Regarding subject-matter content in particular, curricular guidelines present quite

an extensive program. National guidelines set it between 50 and 60% of the workload, although in some provinces it is higher (Federal Board of Education, 2007d). This is the field in which the programs for each particular subject-matter differentiates itself, for subjects acquire higher specificity. For instance, the program for Biology teachers presented in Annex 1 includes 17 subject-matter courses. Four of these courses include basic knowledge in Mathematics, Physics and Chemistry, with the goal of providing teachers with a broader understanding of science. The other 13 are specifically focused on Biology: General Biology, Cellular and molecular Biology, Animal Biology I and II, Plant Biology I and II, Ecology, Biology of microorganisms and fungi, Genetics and biotechnology, Human Biology, History of life on Earth and evolution, Environmental Education, Human Biology and health.

Guidelines also promote the integration of different subjects (Hisse, 2014), with the aim of providing teachers with an interdisciplinary approach to science learning. Courses´ descriptions do actually mention the need to establish relationships between them. For example, one of the teaching recommendations for "Cellular and Molecular biology" is to "articulate knowledge with "Basic Chemistry", "Organic and biological chemistry", "Basic biology", "Mathematical and physics models´ workshops" and specific biology contents from second and third years" (Hisse, 2014: 43). Yet, it is not clear for teacher educators how to accomplish that interdisciplinary integration, although guidelines propose "Integration workshops" as special courses where teacher educators can foster that goal.

Finally, pedagogical content knowledge is developed over 2 or 3 specific courses, as prescribed by national guidelines (interestingly, though, the term "pedagogical content

knowledge" as proposed by Shulman (1986) is not mentioned as such within curricular guidelines, but referred as "special pedagogies"). For instance, the curriculum presented in Annex 1 includes 2 courses: Science pedagogy and Science pedagogy: Biology.

As Ferrata (2014) points out, in most programs, there is a strong prevalence of subject-matter content subjects over the development of pedagogical content knowledge. Research has shown that, in most teacher education programs in the country, science methods courses are insufficient, specific pedagogical discussions focused on teaching content are scarce, and there are few formal opportunities to reflect on teaching practices and tools (Adúriz-Bravo, 2009). In addition, some science teacher educators demonstrated deficiencies in the domain of subject-matter content (Adúriz-Bravo, 2009).

**Professional Exercise**

Along with General Education and Specific Education, Professional Exercise is meant to progressively complete teacher training. In this sense, this field of knowledge is proposed as the backbone of teacher education, integrating knowledge contributions from the other fields to analyse, reflect and experiment teaching in different social and institutional contexts (Federal Board of Education, 2007d).

Historically, this was usually considered one of the fields with greater difficulties in the preparation of teachers. For one, field work and professional practice was almost entirely conducted at the end of the program, under vertical approaches which envisioned "practice" as a direct application of "theory" (Federal Board of Education, 2007d). Secondly, there was no specific definition on the content courses at teacher education institutions must address for this phase, only generically described as “workshops” or “seminars”. Consequently, one of the key aspects of the curricular reform initiated in

2007 to improve teacher education was to reinforce Professional Exercise, including experimentation, reflection and innovation as key aspects in this field of knowledge. (Federal Board of Education, 2012b).

To this regard, one of the aspects curricular guidelines particularly emphasize is the need to integrate Professional Exercise with the rest of the fields from the beginning of the program. It is considered of prior importance for teacher students to enrich theory and practice mutually:

> "Professional Practice requires a multi subject-matter approach that combines General and Specific Education contributions, permanently articulating theory and practice. The recommended contents for each year resume and re-elaborate on concepts developed in the other fields through a non-applicationist approach" (Hisse, 2014: 20).

Jurisdictional guidelines establish one Professional Practice subject per year along the whole degree. The very designation of these subjects (Professional Practice I, II, III and IV) suggests certain level of continuity between them. Moreover, when analysing the particular descriptions of each, there are explicit references to contents from other fields of knowledge. For example, it is suggested that "Professional Practice I" integrates contributions from "Educational ethnography" and the use of audio-visual resources, contents addressed by General Education in the first year of training (See Annex 1).

On the other hand, it is clearly stipulated that the total workload for this field of knowledge should be distributed between teacher education institutes and associated secondary schools, where student teachers can perform projects, practice short lessons, obtain helper or tutor positions, etc. However, at this level of curriculum development, the correspondent workload for each learning emplacement is not clearly established. To this regard, we believe that further efforts are needed to establish stronger, more

systematic and bidirectional bonds between teacher education institutes or universities and schools. Particularly, the role of schools and practicing teachers in the training process of future professors should be enhanced during the teaching placement phase and through other prior formative experiences. Furthermore, this should not exclusively depend on the possibilities or willingness of each particular institution, but be fostered and supported by higher levels of management.

Finally, regarding this field´s contents, the importance of developing reflective capacities in student teachers is particularly highlighted. Both national and jurisdictional guidelines define this as a key element for teacher training and professional development. Curricular guidelines emphasize that the ability to reflect on one´s own practice and analyse others´ is essential for teaching, and that teacher education programs should foster it through different practical experiences (including, but not limited to, working on experiences, memories, evidence, narrative accounts, autobiographies, classroom observations, fieldwork, etc.).

Despite recent efforts, it has been pointed out that, still, Professional Exercise is often dissociated from the other fields of knowledge, with the articulation of theory and practice remaining a major challenge for many institutions (Ferrata, 2014). As in many other countries, this is a defying area for teacher educators, and further efforts still need to be done to help student teachers question their traditional epistemological perspectives on science learning and teaching to enrich their own practice (Loughran, 2014). As it has been already mentioned, this challenge implies establishing a closer link between teacher education institutions and schools. In this sense, authors point out that educative institutions and education in general improves when these two entities become centers for

pedagogical innovation (Aguerrondo & Pogré, 2001).

## Beyond reform

Undoubtedly, the current attempt to overcome the system´s fragmentation through the reform process and the creation of the Teacher Education National Institute (INFD) has been of profound importance for the preparation of teachers in Argentina. During the last years, degrees were unified nationwide and national and some jurisdictional teacher education curricular guidelines were successfully revised and updated to meet current standards. At present, teacher education national guidelines are consistent with the results of educational research and with international consensus on the best approaches and practices in science teaching (Pogré, 2010).

Moreover, under the frame of the "National strategy of improvement in science and math education" enacted by the Federal Board of Education, higher education institutes were equipped with information, multimedia and bibliographical resources, and various programs to foster professional development and postgraduate degrees were set into place (Federal Board of Education, 2011b). These initiatives contribute to comply with the basic necessary conditions for quality teacher education, but are not solely sufficient.

There are important challenges that still need to be considered to improve science education in the country. One of the biggest challenges is, perhaps, the inadequacy in teaching strategies and content that still persists both in schools and in teacher education (Adúriz-Bravo, 2009; Ministry of Education, 2007), which promote an enciclopeadic view of knowledge in general and science in particular. To this extent, although curricular guidelines are consistent with globally valued contemporary approaches to

science teaching, there is a clear discordance between what is prescribed and what teachers actually put into practice (Furman & Podestá, 2009; Pasmanik & Cerón, 2005). Despite the rhetoric of constructivist and inquiry-based approaches, when analysing science lessons in both elementary and secondary schools:

> "we see that theoretical explanations and definitions prevail over experiments; there is a strong tendency toward lectures based exclusively on textbooks (…) teaching is generally decontextualized from everyday life and science history; critical thinking is not promoted and students have limited opportunities to speak or write about science phenomena" (Ministry of Education, 2007: 18).

This disconnect is especially worrying, since it is argued that scientific education for citizenship demands a profound revision of its traditional pedagogical approaches.

Researchers in secondary education also point to the increasing difficulties schools encounter to foster meaningful learning experiences and offer a relevant educative proposal (Terigi, 2012).. Not surprisingly, as discussed above, Argentine students have demonstrated low proficiency levels in Science in national and international examinations which assess student competencies and critical thinking (OECD, 2013; UNESCO, 2014). In addition, very few secondary students express their interest in science and scientific or tecnological professional carreers (Polino, 2012).

We therefore consider that an important challenge of educating for scientific literacy in the country involves a transformation of practices from a teacher-centered to a student-centered approach, not only at school, but also at the teacher preparation level. There is an urgent need to overcome the traditions of "rote learning of scientific contents, with a decontextualized understanding of science, away from everyday life, and unrelated to the historical aspects of science, with little development of scientific skills and critical

thinking" (Ministry of Education, 2008: 25).

Along these lines, it has been pointed out that initial stages of teacher education often promote the replication of a type of decontextualized school instruction, which is dissociated and overemphasizes content knowledge (Echeverría, 2010; Northfield, 2003). In turn, this approach models the future teachers strategies, creating an environment in which —through their own experiences as learners— pre-service teachers later become reluctant to adopt alternative ways of teaching (Loughran, 2007).

Moreover, we believe that the need to prepare teachers to make scientific content relevant to the students´ lives does not only imply enriching pedagogical strategies within teacher education programs, but also involves embedding science teaching (and science teacher education) within a more comprehensive understanding of science.

As research points out, fostering a deeper reflection on the nature of science and its incidence on teaching, as well as enhancing future teachers´ understanding of epistemological and historical aspects of science as a human endeavor is, perhaps, one of the biggest debts of the science teacher education system (Adúriz Bravo, 2009). To this regard, student teachers should engage on debates and activities that explore socio-scientific issues, which may provide better understandings of the broad purposes of science as a human endeavor, as well as the value of science learning for the construction of citizenship (European Commission, 2015; Lederman et al., 2014). In addition, we consider that further development of pedagogical content knowledge and pertinent teaching strategies is crucial to provide student teachers with the necessary tools to engage their future students in active learning and inquiry-based activities.

Nevertheless, a critical challenge to address these changes is still the preparation

of teacher educators who, as we pointed out, in many cases have not had personal experiences in research, neither in the natural sciences nor in education. Research has reported that, in many cases, teacher educators hold a distorted and limited idea of the nature of science themselves and have limited capacities regarding the enactment of science practices, as well as a limited understanding of the connections between science, technology and society and how to integrate a more complex vision of science into teaching (Vilches & Gil-Pérez, 2007). Acknowledging this challenge, recent efforts have been undertaken by the INFD in order to offer teacher educators the possibility of engaging in educational research projects, by providing institutional grants and paid time for that purpose, as well as some extra preparation (Serra, 2010). Still, these processes have posed important challenges to teacher educators, who often do not have prior experience in research projects and lack the methodological knowledge needed to design research projects.

In all, we consider that Argentina shows an interesting landscape regarding teacher education, with huge recent efforts undertaken to create a more coherent and articulated system in order to provide a better preparation for all future teachers, including science educators. However, we also believe that there is still an important need to continue revising and improving some fundamental aspects of the system, including efforts to overcome its fragmentation and raise the local capacities of institutions and teacher educators´ teams, recognizing them as key actors in the process of raising the quality and equity of science education for all and fostering educational innovations. More specifically, we have identified the need to build a mutually enriching relationship between the teacher education system and the schools, to promote a more

comprehensive view of science and to foster the development of a wider and more relevant range of teaching strategies across science teacher education programs. Only then, the goal of quality science education for all will be more than a utopia.

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## Annexes

*Annex 1: Jurisdictional curricular framework for secondary level biology teacher education programs - Province of Córdoba.*

| | General Education | Specific Education | Professional Exercise and teaching practice | Institutional definition |
|---|---|---|---|---|
| 1st year | Pedagogy.<br>Socio-anthropological issues in education.<br>Digital and audio-visual languages. | Mathematical models for science.<br>Physics models for science.<br>General Chemistry.<br>General Biology.<br>Cellular and molecular Biology. | Teaching practice I: contexts and educative practice. | 2 curricular units left for institutional definition. |
| 2nd year | Psychology and education.<br>General Pedagogy. | Philosophy of science.<br>Experimentation in Biology.<br>Organic chemistry and Biology.<br>Animal Biology I.<br>Plant Biology I.<br>Biology of microorganisms and fungi. | Teaching practice II: Schools, documented stories and everyday life. | |
| 3rd year | History of Education and policy in Argentina. | Subjects of education and ESI<br>Science pedagogy.<br>History and epistemology of Biology.<br>Animal Biology II.<br>Plant Biology II.<br>Ecology.<br>Human Biology. | Teaching practice III: the classroom: a place to teach and learn. | |
| 4th year | Ethics and citizenship.<br>Problems and challenges in education. | Science pedagogy: biology.<br>Genetics and biotechnology<br>History of life on Earth and evolution.<br>Environmental education.<br>Human biology and health. | Teaching practice IV and teaching placement | |