ABSTRACT

PEREYRA PÉREZ, MARIANA. Chemistry Teachers Preparation, Self-efficacy and Professional Development Needs in Uruguay. (Under the direction of Dr. M. Gail Jones).

Learning to teach chemistry is a complex endeavor. The beginning teacher must learn content knowledge, as well as develop pedagogical content knowledge to engage students in the process of learning. In addition, teachers must have knowledge about their students, the learning environment, and pedagogical skills for critical components of teaching such as class management. The present exploratory study carried out in Uruguay, provides insight into chemistry teachers' preparation, their needs of resources for instructional and laboratory practices, and professional development opportunities. Furthermore, chemistry teachers' beliefs and attitudes about their teaching practices are documented. Given the variety of classroom contexts that Uruguayan teachers are likely to face during their teaching careers, there are significant challenges for reforming and building a strong teacher education program that can help Uruguay achieve excellence in science education.
Chemistry Teachers Preparation, Self-efficacy and Professional Development Needs in Uruguay

by
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DEDICATION

To my mom, Brenda, my children, Juan and Josefina.

To all the people who have collaborated to reach this goal.
BIOGRAPHY

Mariana Pereyra was born in Montevideo, Uruguay in August of 1977. She attended the University of the Republic where she earned her B.S. in Biochemistry. Before graduation in 2001, Mariana begins her teaching and researcher career at Nuclear Research Center, College of Science, where she still works. She taught Quantitative Analytical Chemistry as a laboratory assistant until 2009. Since 2010, Mariana is a lecturer and laboratory professor of Quantitative Analytical Chemistry at the College of Science. She coordinates an interdisciplinary course for freshman and sophomore students at the College of Science and is responsible for the interdisciplinary course Nanotechnology and Biomimesis in Nature. She also teaches in the training course for university teachers, Interdisciplinary Winter School: Problem-Based Learning. In 2013, Mariana earned a Fulbright scholarship and enrolled full-time as a graduate student in the science education Ph.D. program at NC State. During her second year at NC State, she went back home and earned her Ph.D. in Chemistry at the University of the Republic. She looks forward to her future as a specialist in science education.
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# TABLE OF CONTENTS

LIST OF TABLES ........................................................................................................ vii
LIST OF FIGURES ........................................................................................................ ix

CHAPTER 1: Introduction to Education System and Chemistry Teaching Profession in Uruguay
- Introduction and Background .................................................................................. 1
- Education System ..................................................................................................... 2
- Chemistry Teaching as a Profession .......................................................................... 3
- Statement of the Problem ......................................................................................... 6
- Significance of the Study ......................................................................................... 14
- Research Questions .................................................................................................. 15

CHAPTER 2: Literature Review
- Teacher Preparation .................................................................................................. 17
- Science Teacher Preparation ..................................................................................... 18
- Teachers’ Professional Development ......................................................................... 21
- Self-efficacy and Behavioral Change ......................................................................... 21
- Teachers’ Sense of Efficacy ...................................................................................... 24
- Science Teacher Self-efficacy ................................................................................... 26
- Preparing Teachers to Use Technology ..................................................................... 28
- Use of Technology in Teaching and Learning .......................................................... 31

CHAPTER 3: Methodology
- Purpose of the Research ......................................................................................... 34
- Research Questions ................................................................................................ 34
- General Methodology ............................................................................................... 36
- Participants .............................................................................................................. 36
- Survey Instrument Design ....................................................................................... 40
- Interview Protocol Design ....................................................................................... 46
- Procedure ................................................................................................................ 50
- Data Analysis .......................................................................................................... 51
- Limitations of the Study ......................................................................................... 52

CHAPTER 4: Results
- Teacher Preparation .................................................................................................. 53
- Teacher Self-Efficacy and Attitudes Toward Teaching Chemistry ............................. 60
- Chemistry Teachers’ Instructional Practices ............................................................ 67
- Teaching Chemistry: Challenges ............................................................................. 71
- Performance Evaluation and Promotion ................................................................... 73
- Teachers’ Needs ....................................................................................................... 75

CHAPTER 5: Discussion and Conclusion
- Teacher Preparation .................................................................................................. 85
- Teachers’ Self-efficacy and Behavioral Change ....................................................... 88
- Teachers’ Perceived Instructional Needs ................................................................. 92
LIST OF TABLES

Table 3. 1  Select Survey Participant Demographics by Gender, Teaching Experience, and Teaching Grade .............................................................................................................. 37

Table 3. 2  Interview Participant Demographics by Gender, Professional Degree, and Teaching Experience ........................................................................................................ 38

Table 3. 3  Interview results: Participants’ subjects taught outside of chemistry .......................... 39

Table 3. 4  Reliability Data for Teacher Efficacy and Attitudes for Teaching Chemistry Section (Spanish Version) ........................................................................................................ 44

Table 3. 5  Reliability Comparison for Teacher Efficacy and Attitudes Towards STEM (T-STEM) (English Version) and Teacher Efficacy and Attitudes for Teaching Chemistry (Spanish Version) ........................................................................................................ 45

Table 3. 6  Coding Themes ........................................................................................................ 47

Table 4. 1  Survey results: Chemistry teachers’ reported preparedness ........................................ 54

Table 4. 2  Survey results: Spearman’s rho correlation between teachers’ reported overall preparedness and teachers’ self-efficacy in teaching chemistry ........................................ 56

Table 4. 3  Survey descriptive statistics: Teachers’ reported teaching efficacy and beliefs, outcome expectancy, and teacher leadership attitudes ........................................................................ 60

Table 4. 4  Survey results: Teachers’ reported teaching efficacy and beliefs........................................ 61

Table 4. 5  Survey results: Teachers’ self-confidence in their ability to influence student learning through their teaching .................................................................................. 63

Table 4. 6  Survey results: Percentage “strongly disagree”/”disagree” in teachers’ responses about self-confidence in their ability to influence student learning through their teaching practices ........................................................................................................ 66
Table 4. 7 Survey results: Frequency of chemistry teachers’ use of instructional practices to teach chemistry ................................................................. 67

Table 4. 8 Survey results: Frequency and percentage of chemistry teachers’ use of instructional technology to teach chemistry ................................................................. 70

Table 4. 9 Survey results: Two-way analysis of variance (ANOVA) between instructional technology chemistry teachers use in general by gender and experience ...................... 71

Table 4. 10 Interview results: Professional development needed ................................................................. 77

Table 4. 11 Interview results: Professional development needed ................................................................. 78

Table 4. 12 Interview results: Materials and technology resources teachers reported needing for instructional practices ................................................................. 80
LIST OF FIGURES

Figure 1.1  Countries’ and economies’ performance in science as indicated by PISA 2012, including 65 participating countries (OECD countries, OECD partner countries, and invited countries) ................................................................. 11

Figure 1.2  Percentage of students in 6th grade of primary school, classified by performance in science in each country in the SERCE study. ................................................................. 13
CHAPTER 1: Introduction to Education System and Chemistry Teaching Profession in Uruguay

Introduction and Background

Demand has grown for a science and technology workforce since the Industrial Revolution (Cochran-Smith & Villegas, 2015). In the last decade, international organizations such as the UN have outlined strategies to assist countries in providing quality education programs to their population (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2013) and to meet the United Nations Millennium Development Goals upon which 191 countries agreed. These governments agreed on eight objectives including education, eradication of poverty, and sustainable development of countries in harmony with the environment (United Nations, 2015). In 2005, the Uruguayan government implemented a series of reforms aimed at improving the economy by focusing on science and technology (Poder Ejecutivo, 2005). The Ministry of Industry, Energy, and Mining targeted dynamic and knowledge-intensive sectors for promotion: the pharmaceutical industry, the biotechnology sector of the health and agriculture industry, environmental areas, and the nanotechnology sector (Ministerio de Industria, Energía y Minería, 2012). The Uruguay Education Act of 2008 established the National Education System, encompassing educational policies along with policies related to human, cultural, social, technological, scientific, and economic development. Included in the Education Act is a goal to promote creativity and artistic, scientific, and technological innovation (Senado y Cámara de Representantes de la República Oriental del Uruguay, 2009). The law established scientific education as a common branch to other disciplines and proposed the following (loosely translated into English from documents provided by Congress):
Scientific education in social, natural, and exact sciences will have the purpose of promoting the understanding and social appropriation of scientific and technological knowledge for its democratization. It will also involve the dissemination of procedures and methods for their systematic generation, acquisition, and use. (Senado y Cámara de Representantes de la República Oriental del Uruguay, 2009, p. 11)

The first report published by the National Administration of Public Education offered guidelines for science and technology in formal and non-formal education (Dirección Sectorial de Planificación Educativa – Consejo Directivo Central [CODICEN], 2014). In the report, a series of steps were outlined to improve secondary education students’ knowledge of science. One suggestion concerned the introduction of problem-based learning methodology and programs to encourage student participation in activities such as Science Olympiads, scientific camps, and science fairs. Despite advances in the implementation of strategies intended to engage students in relevant scientific topics, the report highlighted the progressive loss of motivation to learn science as schooling proceeds. The conclusion was that a propaedeutic approach (as an introduction to further study in the University) did not include everyday problems but instead emphasized abstract and unappealing content (Dirección Sectorial de Planificación Educativa – [CODICEN], 2014).

Education System

Uruguay’s educational system is centralized and under the purview of the National Administration of Public Education (Administración Nacional de Educación Pública [ANEP]). ANEP is an autonomous state body and is not affiliated with the Ministry of Education and Culture. It was created by law to plan, manage, and administer the public education system at all levels, including primary, secondary, and technical education along with training in non-university tertiary education across Uruguay (Senado y Cámara de Representantes de la República Oriental del Uruguay, 1985). ANEP also supervises private education at the same
levels as indicated above. In its hierarchical structure, ANEP is governed by the Central Board Council (known as CODICEN), which is in charge of the Initial and Primary Education Council (Consejo de Educación Inicial y Primaria), Secondary Education Council (Consejo Educación Secundaria), Technical Professional Education Council (Consejo de Educación Técnica Profesional), and Education Training Council (ANEP, 2009). By contrast, the University of the Republic (Universidad de la República) is an autonomous entity that oversees public education at the university level (Senado y Cámara de Representantes de la República Oriental del Uruguay, 2009). Under the Education Training Council, secondary education is organized in subject-matter departments such as chemistry, physics, astronomy, biology, and history and supervises disciplinary teachers’ preparation. Conversely, the hierarchical organization of the Secondary Education Council includes subject-matter inspection, which supervises secondary teachers’ performance (ANEP, 2007). Although the Secondary Education Council’s duties include guiding, accompanying, evaluating, and qualifying teachers employed by educational institutions, its main objective is to supervise teachers from an administrative perspective. Whereas institutes and centers prepare teachers in the subject matter or disciplines under the regulation of the Education Training Council, teacher instruction is evaluated by subject-matter inspectors.

**Chemistry Teaching as a Profession**

Uruguayan chemistry teachers obtain teaching certificates through non-university tertiary public institutes mentioned above. Nearly 90% of teachers are prepared via one of three institutes under the supervision of the country’s Teacher Training and Professional Enhancement Department: Secondary Teachers Regional Center (Centro Regional de Profesores [CERP]), Teacher Training Institute (Instituto de Formación Docente), and Artigas Teachers' Institute.
(Instituto de Profesores Artigas) (Mancebo & Vaillant, 2000). Since 2008, these three institutions have implemented the National Curriculum for Teacher Education 2008 (ANEP, 2009). The curriculum is organized by common core professional training and disciplinary courses distributed throughout a 4-year degree program. The chemistry teacher education curriculum includes 48 hours of common core training (e.g., general pedagogy, sociology, psychology, research in education) and 78 hours of disciplinary courses (e.g., general chemistry, physical chemistry, and organic chemistry). Additionally, there are 12 hours of teaching practice in the 4th year, included in the subject Didactics III (ANEP, 2007). During the 4th-year teaching practice, each student teacher is in charge of a class of secondary school students and mentored by an experienced chemistry teacher. Graduates are expected to have developed a set of competencies: be a specialist in the corresponding discipline, develop critical thinking about their teaching practices, adapt to new institutional and instructional environments, and carry out the profession with responsibility and ethical sense. Alternatively, educators can enter a teaching career with a bachelor or higher degree in a STEM field without preparation in teaching. Given the scarcity of trained teachers in science, many university students pursuing degrees in engineering, biochemistry, or physics are allowed to teach at secondary school institutions. For many students, teaching is a way to support their university careers and gain experience, although it is not a requirement for degree completion.

When chemistry teachers and pre-service chemistry teachers enter the secondary school system, they can choose to teach in middle school (1st to 3rd grade level) or high school (4th to 6th grade level). High school teachers primarily teach students with strong math skills and interests in pursuing science and engineering in college. Middle school teachers reach a broader audience, including students who are taking chemistry as a mandatory course for non-science majors. In
the first and second grade level of middle school, chemistry is taught within the subject area of physical sciences. Due to the lack of trained chemistry teachers, many teachers teach in different grade levels within the same year and must, therefore, prepare courses for populations of freshmen as well as 6th-grade students. A diverse and heterogeneous student population in terms of the grade level, requires teachers to be trained in strategies that can effectively prepare students for academic success in science and engineering while helping students, who are not going to pursue a scientific career, become scientifically literate citizens. According to Gabel and Stucky (2010), students’ sustained interest in pursuing science majors such as chemistry at the college level depends on how well they perform in middle and high school. Yet even after earning the highest grades (A grade) in chemistry, many students decide not to pursue chemistry as a career because in some topics subject-matter content was beyond their understanding. Moreover, Gabel and Stucky (2010) noted that many excellent students are becoming disinterested in chemistry because of the way it is taught.

From educators’ perspectives, teaching a wide population of students with different learning objectives is challenging. Students are diverse in their social and cultural backgrounds, interests, and needs. According to Van Note Chism (1999), student diversity in the educational system encompasses many categories: older students outside of the traditional age range; more women enrolling in secondary education; an increase in minority students; more open LGBT students; and a rise in the identification of students with learning or physical disabilities. Therefore, in chemistry class as in any other subject-matter, students come into the classroom with varied experiences, distinct ways of seeing the world, and unique learning needs.
Statement of the Problem

Many issues are associated with chemistry teachers’ preparation at public institutions in Uruguay. Teachers were historically trained in the centers of normal schools, with an interest in education, but were completely siloed from centers that generate disciplinary and pedagogical knowledge (e.g., universities). When teachers graduate from their training, they try to reproduce knowledge acquired from others, namely by selecting and prioritizing texts, materials, and authors that seem ‘good to teach’ while relegating to a second level material that is complex, non-enumerative, and not easily assessable (Marrero, 2010). Thus students are not challenged to develop higher order thinking skills and on the contrary they mainly develop cognitive process associated with lower order thinking.

Before 1997, secondary teacher preparation was centralized in Uruguay’s capital of Montevideo, whereas provinces lacked teacher training institutions. Only half of the teachers in Montevideo possessed a teaching degree, and only one in five teachers held a teaching degree in the rest of the country (ANEP, 2007). In 1997, the Secondary Teachers Regional Center (Centros Regionales de Profesores [CERP]) was created in six regions, allowing high school graduates and professionals from different areas to pursue a teaching degree (CODICEN-ANEP, 2005). In some cases, because of the high demand for teachers, student teachers and students from other professions taught at the secondary level without teaching and content knowledge preparation. By 2005, six of the teacher education curricula coexisted among the three institutions for teacher education (ANEP, 2007).

The National System of Teacher Training was created in 2008, including the National Curriculum for Teacher Education 2008 (ANEP, 2009), an initiative that proposed unifying teacher preparation under a common national curriculum for training teachers. Although the new
The curriculum was expected to achieve national coverage by 2009, many institutions have not yet implemented the changes. Today, secondary school institutions have a new generation of teachers equally competent in disciplines such as chemistry, history, geography, and literature; however, schools still employ teachers whose training was completed prior to 2009 and those with no teaching preparation at all. The last record of student teachers enrollment in chemistry courses indicated a student attrition rate of approximately 80% from the 1st to 4th year of enrollment (Andenauer-Stiftung, 2014). The freshmen population of prospective teachers was 365 but fell to 72 by Year 4. Unlicensed teachers from middle school reached 46.6%; the proportion of high school teachers reached 34.5% across all disciplines. As of 2006, fewer than 70% of chemistry teachers were licensed in Uruguay on average, with the rate of licensure varying from 81% in the province of Paysandú to 13% in the province of Treinta y Tres (CODICEN-ANEP, 2008).

The quality of education relies on numerous factors including universal access to education, the number of students per teacher, and the days of school attendance (Hightower, Lloyd, & Swanson, 2011). Grade repetition and attrition rates, students’ performance, and teacher quality are also influential (Creemers & Kyriakides, 2010). In Uruguay, educational quality as measured by teachers’ performance is constrained by an archaic evaluation system. At the school level, teachers’ performance evaluations depend on one subject-matter inspector visit during the school year. The evaluation focuses primarily on administrative issues: the daily plan, the teacher’s attendance, and the extent to which the teacher’s activities align with the curriculum throughout the school year. Teachers are promoted on the basis of seniority rather than performance or merit. Pursuing a master or Ph.D. degree, professional development courses, or extracurricular activities such as tutoring a student science club are not considered merits. In
some cases, a teacher tutoring for science fairs during school hours is classified by the principal as non-attendance, penalized by a corresponding salary deduction.

Uruguay’s population generally perceives teachers as underprepared to manage student behavior. Teaching is not a high-status profession: wages and working conditions are poor, initial training is of low quality, and opportunities for professional development are limited (UNESCO, 2013). In many cases, authorities hold teachers responsible for students’ low performance despite the absence of national standardized tests to measure student performance or standard evaluations to assess the quality of education offered across institutions. Students’ performance is instead measured according to international evaluations. Since 2013, Uruguay has participated in international assessments to evaluate students’ performance in mathematics and science, such as via the Program for International Student Assessment (PISA) and Second Regional Comparative and Explanatory Study (SERCE). In each case, Uruguay performed well in science among South American nations and was tied for first place with Chile. Yet compared with countries outside the region, Uruguay ranked 54th of 65 countries in the PISA assessment (Organization for Economic Co-operation and Development [OECD], 2014a). The performance of Latin American countries in science, mathematics, and reading was within the lower third of participants (Figure 1.1).

A comprehensive analysis, comparing data from PISA 2006, 2009, and 2012, enabled researchers to monitor students’ average performance over time to examine how and to what extent countries are progressing toward providing all students with the learning opportunities and skills needed to become active participants in a knowledge-based society (OECD, 2014b). Uruguay’s science score dropped two points per year from 2006 to 2012; student performance in 2006 score was 428 but 416 out of 700 points maximum in 2012. Students from countries that
performed similarly to Uruguay in 2006 (e.g., Thailand, Turkey, Bulgaria, Chile, Serbia, and Romania) demonstrated increased performance in 2012 compared to 2006. Researchers further concluded that having students who perform at the highest assessment levels (i.e., Level 5 or 6)\(^1\) can promote competitiveness and innovation in those countries (Bos, Ganimian, & Vegas, 2013). However, only 1% of students in Uruguay reached either Level 5 or 6, whereas Shanghai (China) had the largest population of students performing at those levels (27.2%). Students who do not reach the minimum performance competencies (Level 2)\(^2\) in science, mathematics, or reading can only solve simple problems, and most are not expected to continue their education or enter university (OECD, 2014b). Forty-seven percent of Uruguay students score at Level 2, and their

\(^1\) **Level 6 (lower score limit 708):** “At Level 6, students can consistently identify, explain and apply scientific knowledge and knowledge about science in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that center on personal, social, or global situations” (OECD, 2014b, p. 61).

**Level 5 (between 633 to 708):** “At Level 5, students can identify the scientific components of many complex life situations, apply both scientific concepts and knowledge about science to these situations, and can compare, select and evaluate appropriate scientific evidence for responding to life situations. Students at this level can use well-developed inquiry abilities, link knowledge appropriately, and bring critical insights to situations. They can construct explanations based on evidence and arguments based on their critical analysis” (OECD, 2014b, p. 61).

\(^2\) **Level 2 (between 409 to 484):** “At Level 2, students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving” (OECD, 2014b, p. 61).
performance in problem solving is lower than expected. According to OECD, if countries seek to increase the proportion of students performing at the highest levels and reduce the proportion of students below Level 2, countries could reach the global economic output of OECD countries\(^3\) by around USD$200 trillion. In the case of Uruguay, increasing the percentage of students with Level 2 proficiency and above, would allow more students to enter to the university and generate economic improvement in the near future.

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\(^3\)OECD countries are Japan, Finland, Estonia, Korea, Poland, Canada, Germany, the Netherlands, Ireland, Australia, New Zealand, Switzerland, Slovenia, the United Kingdom, Czech Republic, Austria, Belgium, France, Denmark, United States, Spain, Norway, Hungary, Italy, Luxembourg, Portugal, Sweden, Iceland, Slovak Republic, Israel, Greece, Turkey, Chile, and Mexico. Uruguay is a partner country (OECD, 2014b).
Figure 1. Countries’ and economies’ performance in science as indicated by PISA 2012, including 65 participating countries (OECD countries, OECD partner countries, and invited countries). Source: OECD, 2014a.

The SERCE (Second Regional Comparative and Explanatory Study) study is part of global actions by the UNESCO Regional Office for Education in Latin America and the
Caribbean (OREALC/UNESCO), intended to gather information about the performance of students in mathematics, reading and natural sciences, and offer all Latin American and Caribbean students a quality education. Results of the last study showed that school location (i.e., rural or urban) and the production and distribution of income are the main drivers behind inequitable distribution of learning across social strata (Valdés et al., 2008). Additionally, the study revealed other factors associated with students’ performance beyond cognitive achievements, such as the school environment and socioeconomic, cultural, and demographic factors (Valdés et al., 2008). Sixth-grade primary school students from Uruguay scored above the average in natural sciences (540 compared to 505 points of the average) for Latin America and Caribbean countries; 50% of students scored at Level II\(^4\) out of IV\(^5\) (Figure 1.2), and 3% scored at Level IV. Cuba earned a score higher than the regional average, with 65% of students performing at Levels III and IV. In terms of school location, Uruguayan students demonstrated higher science scores in urban schools than rural.

\(^4\)Level II (lower score limit 472.06): at Level II, students can digest information presented in different formats, which requires more complex information processing skills (Valdés et al., 2008).

\(^5\)Level IV (lower score limit 704.75): at Level IV students are able to identify the scientific knowledge involved in a problematic situation. They transfer scientific knowledge, which requires a high degree of formalization and abstraction to different situations (Valdés et al., 2008).
Figure 1.2. Percentage of students in 6th grade of primary school, classified by performance in science in each country in the SERCE study. Students with higher achievement are expected to perform at Level III or IV. Source: (Valdés et al., 2008)

Although Uruguay has not participated in international assessments evaluating specific students’ performance in chemistry (i.e., Trends in Mathematics and Science Studies), the results of science tests in SERCE study and PISA assessment have indicated that students do not possess acceptable levels of competence; specifically, students are not competitive in a market where higher cognitive skills are required to solve complex global problems. The Royal Society of Chemistry’s report entitled “Chemistry for Tomorrow’s World” pointed out major priorities and challenges related to global sustainability that chemical science must address in the 21st century (Royal Society of Chemistry, 2009). The report identified seven areas to prioritize, such as energy, air and water, human health, and raw materials. According to Zoller (2012), sustainability refers to “the capability of evaluative system thinking in the context of science, technology, environment, and society, which in turn requires the development of students’ higher-order cognitive skills (HOCS), system critical thinking, question-asking, decision-
making, and problem solving” (p. 297). Therefore, chemistry and science education should promote these skills to enable students to apply them in disciplines beyond science and to address complex problems in the future.

In light of the low performance of students in Uruguay in science on an international scale, and the corresponding social and economic consequences, policymakers invested in the education of future generations should strive to develop medium- and long-term strategies to address these problems. In a world where science and technology are increasingly the engines of countries’ economies, chemistry cuts across the main strategic areas of development. Teachers, who are the pillars of the education system, must be better prepared and be given the resources to improve their teaching practices.

The present exploratory study was conducted in Uruguay and intended to address teacher education, including self-efficacy and attitudinal aspects of teaching chemistry. Findings provide insight into chemistry teachers’ preparation, the resources required for instructional and laboratory practices, and professional development opportunities.

**Significance of the Study**

This study examined the preparation of chemistry teachers in Uruguay, their sense of efficacy about teaching, and their needs for resources and professional development opportunities. A culture of evidence based on scientific research is paramount to offering recommendations for improvement in education. Although studies have been conducted regarding teachers’ self-efficacy and beliefs in many countries, this study is the first of its kind in Uruguay. Data on teachers’ self-efficacy and beliefs around teaching science, particularly chemistry, are scarce. The results of this study can inform recommendations for resources and
professional development to help chemistry teachers improve their teaching practices, perceptions of student outcomes, and beliefs and attitudes about teaching.

These findings may also be useful in planning and developing educational policies to improve science teacher education in Uruguay and can serve as a foundation for future studies, including program administration. Uruguayan teachers face unique problems during their teaching careers that present significant challenges. Policies aimed at establishing a strong teacher education program can aid Uruguay in achieving excellence in science education.

**Research Questions**

This study examines the following research questions:

Research Question 1: *What preparation do chemistry teachers in Uruguay receive to prepare them to teach?*

a. Do chemistry teachers report feeling prepared to promote student learning and teach critical thinking and social development?

b. Do chemistry teachers report being able to identify students’ learning needs?

c. Do chemistry teachers report participating in professional development activities?

d. Are there differences between experienced and novice chemistry teachers’ sense of preparedness to teach chemistry?

e. What is the relationship between chemistry teachers’ sense of preparedness and self-efficacy for teaching chemistry?

Research Question 2: *What is the state of chemistry teachers’ self-efficacy and attitudes toward teaching chemistry?*

a. Do Uruguay chemistry teachers feel confident in their ability to teach chemistry?
b. Are there differences in novice and experienced chemistry teachers’ self-efficacy regarding teaching chemistry?

c. Do Uruguay chemistry teachers feel confident in their ability to promote student learning in chemistry?

Research Question 3: What instructional practices do chemistry teachers use?

a. What instructional practices do chemistry teachers report using to teach chemistry?

b. Are there differences between novice and experienced chemistry teachers’ reported instructional practices?

c. What is the relationship between chemistry teachers’ reported experience, and the instructional technologies they use most often to teach chemistry?

d. Is there a correlation between chemistry teachers’ sense of preparedness around technology and how often they use technology while teaching?

Research Question 4: What resources and professional development opportunities do chemistry teachers in Uruguay report needing for instruction?

a. What are the differences in resources available to teachers in rural and urban schools in Uruguay?

b. What additional resources do Uruguay chemistry teachers report needing to improve their instruction?

c. What are Uruguay chemistry teachers’ perceived needs for professional development to improve their instruction?

d. Are there differences between rural and urban chemistry teachers’ needs for professional development?
CHAPTER 2: Literature Review

Teacher Preparation

Social, political, and economic forces have shaped teacher preparation in many ways over the years (Cochran-Smith & Villegas, 2015). In terms of education policy, changes in the productive matrix of countries (i.e., transforming from an economy based on industrial manufacturing to a global and competitive knowledge society) have exerted great influences on teacher preparation and relevant policy. Many politicians, policymakers, and researchers around the world have agreed that teachers have a key influence on student learning (Fackler & Malmberg, 2016). Accordingly, many countries have placed high expectations on teachers in terms of teaching students to reach world-class standards, embrace educational reform, and help decrease social inequalities.

Teacher preparation is a complex field with a main objective of education. According to Cochran-Smith and Villegas (2015), three trends shaped the development of studies of teacher preparation programs: teacher quality and accountability; a paradigm shift around how students learn and what they need to know; and diversity in the student population along with social and school inequalities. In recent decades, teacher preparation has focused on providing teachers with tools that allow them to navigate an increasingly diverse student population amid growing social and school inequalities (Fuchs, Fuchs, & Bishop, 1992). New demands on teachers have shifted the emphasis in teacher education from traditional didactic instruction to different models focusing on student needs. Although teacher preparation programs have been designed to provide all students with high-performing teachers (including in high-demand subject-matter areas) and teachers prepared to work in highly diverse and low socioeconomic contexts, teachers noted two decades ago that their training has not prepared them to deal with the complex
situations they face in their classrooms (Dembo & Gibson, 1985). Teachers have further contended that they received little or no preparation for various situations that arise in modern society such as students with learning disabilities, or heterogeneous population of students.

With the goal of preparing qualified teachers to fulfill growing demand in schools, especially low-performing schools, educational policies in U.S. have focused on providing fast-track alternatives to classical training such as that gained through university-based studies (Johnson, Birkeland, & Peske, 2005). Several studies have investigated certification programs and alternative pathways for teacher preparation (Cochran-Smith & Villegas, 2015). Scholars have recommended providing prospective teachers with more content-based pedagogy in fast-tracks alternatives training (Johnson et al., 2005). Steadman and Simmons (2007) argued that teachers from non-university certification programs require more intense mentoring than traditionally trained teachers. Teachers prepared through traditional teacher education programs have reported feeling better prepared to teach than those trained through alternative programs or without preparation (Darling-Hammond, Chung, & Frelow, 2002). Teachers who report feeling well-prepared to teach have been found to possess higher teaching self-efficacy and increased beliefs that they can improve student achievement.

Science Teacher Preparation

Many teacher education programs emphasize teaching conceptual knowledge of science instead of the nature of science (NOS) as a human construction (Fensham, 2011). According to Fensham (2011), science teachers in today’s knowledge society must be able to teach about specific aspects of science: how scientific thinking occurs; the ways in which science is communicated between scientists and the population; strategies for students to learn science, such as learning with others in science classrooms; the ability to adapt in science; the various
ways in which a research question can be addressed; and the components that comprise a solution to a scientific problem.

Among science teachers, the concept of NOS has not been accepted in its entirety, and their knowledge about the epistemology and history of science is limited (Van Driel, Verloop, & DeVos, 1998). Researchers argued that science teachers also tend to believe that knowledge in science remains fixed over time. According to Vesterinen, Aksela, and Sundberg (2009), the nature of chemistry is part of the NOS and includes historical, sociological, and philosophical perspectives on chemical practice as well as reflection on the roles of chemistry education and chemistry as a research field in society. The nature of chemistry is thus related to scientific literacy and technological literacy (Vesterinen et al., 2009).

When chemistry content is taught in the classroom, students’ performance in chemistry-specific situations varies by context. For example, Walpuski and colleagues (2012) found that students’ decision-making skills, as part of a solution identification process, were poor during activities focused on scientific contexts but improved with a focus on daily contexts (Walpuski et al., 2012). Moreover, given the uncertainty and complexity of science, teachers need to incorporate the concepts of risk and probability to develop pedagogies consonant with these concepts. International assessments have led science teachers to evolve in their pedagogical practices, such as by providing real-world science and technology examples and exploring the interaction of different knowledge areas with science (Fensham, 2011).

Because the approach of science teaching takes a student-centered approach with an emphasis on laboratory activities, high school chemistry teachers require specific training and tools to determine which laboratory programs are most appropriate for their students (Sitzman, 2015). Chemistry teachers should also be able to address Gabel’s (1999) identified barriers to
learning chemistry, including the complexity of chemical concepts, unfamiliar materials, the structure of the discipline, and language, all of which influence how students process the information they receive from teachers. Therefore, teachers must be aware of students’ prior knowledge, interpretation of new concepts, and the complexity of understanding the linkages between macroscopic, particulate, and symbolic levels of matter (Johnstone, 1991).

Many studies have revealed pre-service and in-service chemistry teachers’ challenges in understanding basic chemistry concepts at the macroscopic, symbolic, and particulate or microscopic levels (Johnson et al., 2005; Tuysuz et al., 2011). Essentially, scientific concepts can be represented in a threefold manner. The macroscopic level refers to observable phenomena, namely tangible instances that children and adults experience and then create concepts of what they can see or touch. However, the symbolic and particulate levels are not connected to phenomena in everyday life and cannot evolve from sensory input; thus, one’s mental constructions, capacity for abstraction, and imagination are key in understanding chemistry at these levels (Johnstone, 1991). The use of metaphors, analogies, and models is needed to teach abstract concepts in chemistry (Gabel, 1999). According to Gabel (1999), chemistry teachers must understand this threefold relationship to present these levels in ways students can understand.

Increasing demand for science teachers has resulted in many teachers being given teaching assignments that do not match their certification; in other words, teachers receive assignments for which they are not prepared. Studies in U.S. schools have shown that approximately 22% of public-school teachers in secondary science classrooms held neither a major nor a minor in their assigned field, and this percentage reached 32% in high-poverty-area schools. Additionally, only 25% of chemistry teachers have degrees in their field compared with
53% of biology teachers (Sitzman, 2015). Many chemistry teachers were found to possess relatively limited area knowledge; merely 43% had completed three or more chemistry courses beyond the introductory level, and 11% had only taken introductory chemistry (Sitzman, 2015). In developing countries like Uruguay, although official statistical data are unavailable, the figures are at best consistent with these data and may even be worse, unveiling an urgent problem (CODICEN-ANEP, 2008).

**Teachers’ Professional Development**

Research on teachers’ professional development has revealed that effective professional development should include continuous teacher support through tutoring and mentoring, curricular alignment, collaboration among teachers, more than 50 hours of training activities, and multiple opportunities for classroom application (Lumpe, Czerniak, Haney, & Beltyukova, 2012). According to Desimone (2009), teacher professional development should improve teachers’ knowledge, skills, and instructional practices to include a content knowledge approach, active learning activities, and collective participation. Whether through individual activities (e.g., college or special institute courses, workshops, or local and national conferences) or interactive and social practices, professional development can enhance teachers’ growth (Desimone, 2009).

**Self-efficacy and Behavioral Change**

Excellence in teaching has been tied to high teacher self-efficacy. Self-efficacy refers to an individual’s belief that he/she can achieve a specific level of performance (Bandura, 1977; Bandura & Adams, 1977). Self-efficacy reflects confidence in one’s ability to exert control over his/her motivation, behavior, and social environment; the construct therefore determines how people feel, think, behave, and motivate themselves (Bandura, 1994). Under the theory of behavioral change, Bandura distinguished between outcome expectancy and efficacy.
Whereas outcome expectancy refers to an individual’s judgments about behavioral consequences leading to certain outcomes, **efficacy expectation** is an individual’s commitment to achieving a level of performance to produce those outcomes (Bandura, 1977). According to Bandura (1977), “efficacy expectations determine how much effort people will spend and how long they will persist in the face of obstacles and aversive experiences” (p. 194).

Perceived self-efficacy is derived from four principal dimensions: **performance accomplishment** (mastery experience), vicarious experience (a model’s behavior), verbal persuasion (social persuasion), and psychological states (mood) (Bandura, 1977). **Personal accomplishment** is based on personal mastery experiences, wherein efficacy expectations arise from personal accomplishments. Individuals with high appraisal of their capabilities approach difficult tasks as challenges to be mastered rather than threats to be avoided. A resilient sense of efficacy requires experience in overcoming obstacles through effort. Moreover, in the face of failure, people heighten their self-motivated persistence if they realize through experience that difficult obstacles can be mastered by sustained effort. Personal mastery expectations influence performance and are shaped by the cumulative effects of one's efforts (Bandura, 1977). **Vicarious experiences** rely on inferences from social comparison; seeing people similar to oneself succeed and surmounting threatening activities strengthens observers’ confidence in their capabilities to master comparable activities to succeed (Bandura, 1994). Vicarious experience is a cognitive process of observational learning where the acquisition of a new behavior pattern is performed and modeled by observing others and later refined through self-corrective adjustments (Bandura, 1977). **Verbal persuasion** arises as a consequence of being influenced by what others have to say about one’s capabilities. People who are persuaded verbally into believing they can cope successfully with certain activities are more likely to expend and sustain greater effort than if
they experience self-doubt or rely on disconfirming experiences (Bandura, 1977). Individuals’ psychological states influence their interpretations of their emotional and physical reactions. Stress and tension can indicate vulnerability to poor performance in some but facilitate performance in others (Bandura, 1994).

According to Bandura (1994), teachers’ self-efficacy shapes people’s behavior through four psychological processes: cognitive, motivational, affective, and selection. Cognitive processes refer to potential scenarios people construct and rehearse, which play prominent roles in the acquisition and retention of new behavior patterns. Individuals with high self-efficacy predict successful scenarios leading to performance accomplishments; those who doubt their efficacy visualize failure scenarios and become erratic in their analytic thinking, causing the quality of their performance to decline (Bandura, 1994).

Self-efficacy beliefs influence motivation in many ways and are crucial to the self-regulation of motivation. Motivation is cognitively generated and is regulated by outcome expectancies (Bandura, 1977). Setting goals serves as a source of motivation and involves self-evaluation based on standards against which performance is evaluated. Setting challenging goals enhances and sustains people’s motivation by self-rewarding persistence until individuals fulfill their goals. Affective processes refer to individuals’ perceived self-efficacy in exercising control over stressors and how they cope with threatening or difficult situations. People who believe they cannot manage threats experience high anxiety arousal, whereas people with strong self-efficacy can control distressing thoughts. Selection or choice-related processes refers to people’s capability to choose beneficial environments where they judge themselves capable of handling situations. Career choice is an example of how personal efficacy can shape one’s life trajectory; the higher one’s perceived efficacy, the broader his/her array of perceived career options and the
better prepared he/she is to achieve the performance required for a given occupation (Bandura, 1994).

**Teachers’ Sense of Efficacy**

Research on teacher efficacy tends to be grounded in Bandura’s social cognitive theory and his construct of self-efficacy (Bandura & Adams, 1977). Guskey and Passaro (1994) described teachers’ beliefs as convictions that teachers can influence student learning whenever students may be challenging or unmotivated. Bergman, McLaughlin, Bass, Pauly, and Zellman (1977) defined teachers’ sense of efficacy as “the extent to which the teacher believed he or she has the capacity to affect student performance” (p. 137). Dembo and Gibson (1985) identified five variables that influence teachers’ self-efficacy: “teacher preparation, teacher socialization, personal teacher variables, school organization, and parent-teacher relations” (p. 177). They found that different school organizations, along with teachers’ classroom behavior (e.g., feedback provided to students with difficulties and time spent in whole-group instruction), were associated with teacher efficacy.

Many studies have shown that teacher efficacy predicts numerous critically important variables such as student achievement and motivation (Ashton & Webb, 1986; Bergman et al., 1977; Tschannen-Moran, Woolfolk-Hoy, & Hoy, 1998), school effectiveness (Fleckenstein, Zimmermann, Köller, & Möller, 2015; Hoy & Woolfolk, 1993), teachers’ adoption of innovations (Guskey, 1988), teachers’ professional commitment (Coladarci, 1992; Ware & Kitsantas, 2007), teachers’ classroom management strategies (Woolfolk, Rosoff, & Hoy, 1990), career success (Abele & Spurk, 2009), teacher absenteeism (Gaziel, 2004), and teacher stress (Parkay, Greenwood, Olejnik, & Proller, 1988). Additionally, teacher burnout (Brouwers & Tomic, 2000; Evers, Brouwers, & Tomic, 2002) was identified as a predictor of program
implementation (Bergman et al., 1977; Guskey, 1988).

According to Bandura (1993), self-efficacy contributes to students’ academic performance in three ways: students’ self-efficacy, which influences their learning process; teachers’ self-beliefs of their efficacy to promote and motivate students’ learning; and faculty’s collective sense of efficacy that contributes to their school’s academic achievement.

Mastering academic activities can promote students’ motivation and academic accomplishment. Likewise, teachers’ beliefs determine the environment where learning takes place and in turn influence their students’ academic progress. Collective teacher efficacy is a social perception based on an assessment of the school faculty’s collective capability, which can influence how teachers instruct and motivate students and manage their classrooms (Tschannen-Moran & Barr, 2004). Teachers with a high sense of efficacy have been found to spend more classroom time on-task to improve academic learning, assist students having difficulties, and reward students for their achievements (Bandura, 1993). The combination of teachers’ high sense of efficacy, strong collective beliefs, and the alignment of staff development with the values and attitudes of the educational institution can contribute to higher student outcomes (Bandura, 1997).

The source of self-efficacy beliefs appears to differ between novice and experienced teachers. Whereas novice student teachers tend to rely on contextual factors such as teaching resources and interpersonal support, these aspects have less influence on experienced teachers’ self-efficacy (Tschannen-Moran & Hoy, 2007). Scholars have found that job tension and job discontent can adversely affect novice teachers’ self-efficacy (Helms-Lorenz & Maulana, 2015). Teachers who perceive themselves as having a low sense of effectiveness are more likely to be unmotivated to change their teaching practices because they believe they lack the skills needed to
modify their practices in the future (Tschannen-Moran et al., 1998). However, more experienced teachers with higher levels of self-efficacy have reported more mastery experience in classroom management and student engagement (Malmberg, Hagger, & Webster, 2013).

The contexts where teaching practice occurs influence teachers’ self-efficacy in specific ways. Moseley, Bilica, Wandless, and Gdovin (2014) studied the relationship between the teaching efficacy and cultural efficacy of novice science teachers in high-need, high-minority urban schools. Findings revealed a relationship between teaching efficacy and cultural efficacy through cultural connections with students. When teachers developed empathy and engaged with their students’ cultural backgrounds, social relationships, and home lives, they were able to cultivate relationships through socio-cultural connections, and their sense of efficacy increased. Moreover, Tucker and colleagues (2005) found that teachers with higher self-efficacy believed they could affect student learning in a diverse student population despite external factors such as low socioeconomic status or lack of student motivation.

Studies regarding the influence of professional development on teachers’ self-efficacy have shown that changes occur in teacher attitudes and beliefs given evidence of improvement in student learning following teacher-directed shifts in classroom practices; such modifications include new instructional approaches, the use of new materials, or changes in classroom format (Guskey, 2002). Professional development experiences can negatively influence teachers’ self-efficacy if gaining more knowledge about content and instructional strategies generates overconfidence or uncertainty (Yoo, 2016).

**Science Teacher Self-efficacy**

Science teachers’ beliefs about their teaching efficacy have been studied from different perspectives. Instructors’ lack of confidence in teaching science has led researchers to study the
factors influencing science teachers’ beliefs about and attitudes toward their teaching practices. From investigating the influence of professional development activities on teaching practices (Enderle et al., 2014; Ross & Bruce, 2007) to the correct use of chemistry concepts (Schoon & Boone, 1998) and implementation of curricular innovations (Temiz & Topcu, 2013), various findings are applicable to teacher preparation for science teaching. Professional development opportunities present a potential source of increased confidence among science teachers.

Researchers studying science teachers participating in a Research Experience for Teachers program observed an increase in teachers’ efficacy with respect to their ability to teach science. According to Enderle et al. (2014), research experiences gave teachers an opportunity to gain confidence in delivering effective science teaching in the future despite teachers’ expectations that improved teaching practices would translate to better student outcomes.

Avery and Meyer (2012) assessed the impact of an inquiry-based science course on elementary teachers’ efficacy and identified positive effects on teachers’ self-efficacy for science and science teaching, conceptual understanding of science, and confidence to teach science in the future. Lumpe and colleagues (2012) studied whether a correlation exists between teachers’ participation in professional development programs and student achievement. Results showed that the time devoted to professional development increased teachers’ self-efficacy about teaching science and predicted students’ science achievement. The researchers assumed that other factors, such as classroom practices, curriculum materials, support systems, and student background variables, might also influence teachers’ beliefs (Lumpe et al., 2012). A recent study indicated that an attitude-focused professional development approach enhanced primary teachers’ self-efficacy beliefs regarding science teaching; teachers also became dependent on contextual factors and experienced lower anxiety (van Aalderen-Smeets & van der Molen, 2015).
A positive correlation was identified between science teaching attitudes, science teaching efficacy, and science teaching outcomes expectancy among pre-service elementary teachers who participated in extracurricular science activities (Kirik, 2013).

These findings suggest that student teachers may be more likely to develop high science teaching efficacy and outcome expectancy over the course of their teaching preparation program, which then positively influence their future students’ understanding of science. According to Zeldin, Britner, and Pajares (2008), sources of self-efficacy differ by gender. A comparative study of self-efficacy among successful men and women in mathematics, science, and technology careers revealed that for women, social persuasion and vicarious experiences were the primary sources of self-efficacy beliefs. For men working in these traditionally male-dominated domains, self-efficacy tended to arise from men’s interpretations of their ongoing achievements. Together, these results indicate that distinct sources shape the creation and development of self-efficacy among men and women pursuing STEM careers. Such sources may therefore be used to inform science teacher training and professional development.

Preparing Teachers to Use Technology

The U.S. Department of Education developed the National Education Technology Plan in 2017 with the aim of preparing all pre-service teachers with the skills to adequately assess, classify, and use appropriate resources and technology to develop activities to promote students’ agency over their learning. The plan increased access to high-speed internet connections in schools and classrooms to afford more students technology-based learning opportunities and provide professional development for in-service teachers. Many agencies such as the Council for the Accreditation of Educator Preparation provide accreditation to education preparation programs, certifying that teachers meet specific technological standards. However, many pre-
service teachers have reported feeling unprepared to use technology effectively in their teaching practice since starting in-service teaching (U.S. Department of Education, 2017). Local governments and schools have thus implemented a series of measures, one of which involves educating novice teachers in standardized basic practices for technology use and instructional strategies. However, the time it takes to train teachers through these refresher courses, coupled with constant changes in teaching staff, can render such measures infeasible (U.S. Department of Education, 2017).

In 2007, the Uruguayan government launched the Ceibal Plan initiative (Ceibal refers to Basic Informatics Educative Connectivity for Online Learning) inspired by Nicholas Negroponte’s non-profit project, One Laptop Per Child, with the aim of using technology to support educational policies and build social equity through information and communications technology (ICT). According to the government, the program provides low-income children access to technology and promotes educational change processes. Since its implementation, every student in Uruguay’s public education system has received a computer for personal use along with free internet. The program has also focused on offering teachers professional development programs. Educational technology programs range from teaching content knowledge using technology such as an adaptive mathematics platform to learning to use technology as a tool (e.g., virtual reality, robotics, programming, and 3D printing). The program also planned to universalize English teaching, digitize textbooks, and promote digital inclusion of students and their families. Resultant programs and platforms include the following: digital technology laboratories; Ceibal in English, Ceibal digital library; interactive, activities such as

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6Nicholas Negroponte is the founder and Chairman Emeritus of Massachusetts Institute of Technology’s Media Lab and founded the One Laptop per Child Association.
video games and apps; an educational social network; an adaptive mathematic platform; an Artists and Scientists in the Classroom initiative; a learning assessment system; and an electronic attendance system (Uruguay Estudia). The program also provides support to teachers through the Department of Education, which offers refresher training as professional development. The training is framed in a broad and flexible way that allows teachers to forge their own path. However, courses are not mandatory and can be completed based on teachers’ interests. Teachers can enroll in a variety of face-to-face, virtual, and hybrid courses, workshops, and projects according to their needs. Teachers also receive support through personalized support plans for teaching groups, open-access educational resources, a resource repository, practice communities, and personalized learning environments (Brechner, Luaces, Moraes, & Borchardt, 2017).

Despite the promise of Ceibal Plan, few studies have been conducted to evaluate its impact on student learning and teaching practices; however, several reports have warned the program may not be all it seems. A World Bank report on national educational technology agencies around the world highlighted the problems associated with implementing a program outside of the education system (Trucano & Dykes, 2017). Beyond technical issues related to implementation and logistics, the program lacks complementary strategies to ensure teachers’ professional development, availability of appropriate digital educational resources, and provision of technical and pedagogical support (Trucano & Dykes, 2017). A recent systematic review of academic research published in the first decade since the program's implementation (from 2007 to 2017) and indexed in Web of Science, Scopus, and ERIC databases showed that most students did not use the laptops at school, and teachers had not changed their teaching practices (Caballero de Luis, 2017). Students who used their computer in class did so only for internet searches, and they could not evaluate sources adequately. Findings also revealed no substantial
changes in students’ performance on national and international assessments within the last 20 years (i.e., including after the implementation of Ceibal Plan).

Another study examining the didactic use of ICT in mathematics teaching identified no explicit reference in the curriculum to guide work with ICT in middle and high school mathematics courses in Uruguay (Téliz, 2015). Findings also revealed inconsistencies between what teachers think (i.e., their opinions and conceptions) and what they do (their practices). Although teachers expressed optimism toward the use of ICT in their teaching practices, such tools tended not to be integrated into teaching practices and were instead primarily used for Internet research.

Similar results were found in a study on the incidence of innovation processes in ICT in mathematics teaching practices in the first year of secondary education in Uruguay (Vaillant-Alcaide, Rodríguez-Zidán, & Bernasconi-Piñeyrúa, 2015). Results revealed no substantial changes in mathematics teaching practices for most of the teachers surveyed. Despite teachers’ generally favorable perceptions of transformation and improvement in their practices, not all felt competent enough to use technology while teaching. Students’ sociocultural contexts in terms of socioeconomic status and school performance also limited teachers’ innovation initiatives. The proportion of teachers who perceived their teaching practices as having changed significantly after incorporating ICT was lower in teachers working in high schools in low socioeconomic areas (Vaillant et al., 2015). Moreover, less than a quarter of students in all areas brought their laptops to the class.

**Use of Technology in Teaching and Learning**

Today, the use of technology as a tool for teaching and learning is widespread across all levels of educational systems around the world. Technology can support teaching and learning
through the incorporation of digital learning tools such as laptops and handheld devices in the classroom along with increased opportunities for course interaction 24 hours a day, 7 days a week. This immersive environment also allows access to information through specialized web pages on different topics as well as access to libraries around the world in just one click. To introduce these technological tools in the classroom, teachers must be trained in the necessary competencies for technology use.

Flick and Bell (2000) proposed several guidelines on fundamental topics to prepare science teachers to use technology with the intention of facilitating program design and guiding applied measures to support educational reform in the U.S. Suggestions include incorporating technology to teach scientific content, employing technology to address relevant scientific issues using appropriate pedagogies, and making scientific perspectives more accessible. Recommendations also highlight technology instruction to develop students’ understanding of the relationship between technology and science. The guidelines provide tools for teachers to use during science instruction, such as the Global Learning and Observations to Benefit the Environment (GLOBE) project (University Corporation for Atmospheric Research, 2018) in which students can relay meteorological data information on a virtual platform and then manipulate the data according to whether the data are local, national, or global. To promote understanding of scientific inquiry, Flick and Bell (2000) identified tools for displaying and evaluating scientific controversies, such as tools for argumentation and evidence as well as supporting knowledge.

Some studies have focused on teachers’ technology use in their classes and how technology promotes changes in teaching practices. Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, and Sendurur (2012) examined how teachers’ pedagogical beliefs align with the
integration of technology in their teaching practices. Results showed that teachers who used technology successfully were influenced by their personal beliefs and attitudes regarding the relevance of technology to students’ learning. Internal factors, such as passion for technology and external support from school administrators, also influenced teachers’ practices. Teachers’ knowledge and skills related to technology, and their attitudes and beliefs toward it, presented major barriers to teachers’ technology use (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). A longitudinal comparative study was carried out between 2012 and 2017 to identify teachers’ competencies in implementing ICT and technologies for learning and knowledge in their teaching practices in public and private institutions in Latin America (Ehuletche, Lado, Atlante, & Malbernat, 2018). Findings revealed an increase in teachers’ enthusiasm for training to master technological tools. Teachers’ commitment to ICT training was greater when they were motivated. Additionally, teachers with more experience and a positive appraisal of ICT soon incorporated technology into their teaching practices.
CHAPTER 3: Methodology

Purpose of the Research

This study examined secondary school chemistry teachers’ self-efficacy and attitudes toward chemistry teaching. This exploratory research was conducted to seek information about secondary school teachers’ science education preparation in Uruguay; how often they use certain instructional practices, technologies; and their needs for instructional resources, and professional development opportunities.

Research Questions

Research Question 1: What preparation do chemistry teachers in Uruguay receive to prepare them to teach?

a. Do chemistry teachers report feeling prepared to promote student learning and teach critical thinking and social development?

b. Do chemistry teachers report being able to identify students’ learning needs?

c. Do chemistry teachers report participating in professional development activities?

d. Are there differences between experienced and novice chemistry teachers’ sense of preparedness to teach chemistry?

e. What is the relationship between chemistry teachers’ sense of preparedness and self-efficacy for teaching chemistry?

Research Question 2: What is the state of chemistry teachers’ self-efficacy and attitudes toward teaching chemistry?

a. Do Uruguay chemistry teachers feel confident in their ability to teach chemistry?
b. Are there differences in novice and experienced chemistry teachers’ self-efficacy regarding teaching chemistry?

c. Do Uruguay chemistry teachers feel confident in their ability to promote student learning in chemistry?

Research Question 3: What instructional practices do chemistry teachers use?

a. What instructional practices do chemistry teachers report using to teach chemistry?

b. Are there differences between novice and experienced chemistry teachers’ reported instructional practices?

c. What is the relationship between chemistry teachers’ reported experience, and the instructional technologies they use most often to teach chemistry?

d. Is there a correlation between chemistry teachers’ sense of preparedness around technology and how often they use technology while teaching?

Research Question 4: What resources and professional development opportunities do chemistry teachers in Uruguay report needing for instruction?

a. What are the differences in resources available to teachers in rural and urbanschools in Uruguay?

b. What additional resources do Uruguay chemistry teachers report needing to improve their instruction?

c. What are Uruguay chemistry teachers’ perceived needs for professional development to improve their instruction?

d. Are there differences between rural and urban chemistry teachers’ needs for professional development?
General Methodology

Using quantitative and qualitative methods, chemistry instructors’ teaching efficacy, instructional practices, and preparation for teaching in Uruguay were examined. A national online survey was conducted followed by in-depth interviews with a survey subsample. Results of this study provide an overview of chemistry teachers’ practices in Uruguay in their local contexts. Study participants and research instruments are described in the following sections.

Participants

Survey participants. Participants were recruited from several sources: the public database of chemistry teachers on the Secondary Education Council web page; teachers participating in the National Science Fair and in professional development courses; and a social media teachers’ group (a Facebook page for chemistry teachers). Teachers from rural and urban areas and private and public schools in Uruguay were invited to participate in the study; an email invitation (see Appendix A) was sent to chemistry teachers requesting their participation in the survey. Participation was voluntary. All study participants (i.e., those who completed surveys and/or interviews) gave consent to participate (see Appendix B and C), were informed about what participation entailed, and were reassured that they could withdraw from the study at any time without penalty. Teachers who did not complete 50% of the survey or who did not sign the consent form for the interview were excluded from data analysis.

After reviewing the above eligibility criteria, 111 of 114 respondents were selected to participate in the survey (Table 3. 1). Three participants were not included because they completed less than 50% of the survey questions. The sample included 90 women and 21 men from rural and urban areas. In terms of school location, 95% of participants worked in urban areas and 5% worked in rural areas. Some rural schools incorporate early secondary education,
namely the 7th, 8th, and 9th levels, into primary school. Of all basic secondary education centers
(n = 663), 9.2% (n = 61) were identified as rural. Due to the small proportion of participants in
rural schools (n = 5), only descriptive statistics were reported for resources and professional
development questions.

Table 3.1 Select Survey Participant Demographics by Gender, Teaching

<table>
<thead>
<tr>
<th>Experience, and Teaching Grade</th>
<th>n</th>
<th>Sample Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>90</td>
<td>81</td>
</tr>
<tr>
<td>Male</td>
<td>21</td>
<td>19</td>
</tr>
<tr>
<td>Teaching experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One year</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td>2–5 years</td>
<td>33</td>
<td>30</td>
</tr>
<tr>
<td>6–10 years</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>&gt; 10 years</td>
<td>52</td>
<td>46.3</td>
</tr>
<tr>
<td>Teaching grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle school</td>
<td>47</td>
<td>42.3</td>
</tr>
<tr>
<td>High school</td>
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<td>50.5</td>
</tr>
<tr>
<td>Teacher education</td>
<td>8</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Note: N = 111.

Ethnically, participants were African/Black (n =1), Asian (n =1), European/White (n =86), and Native or Indigenous (n =5). Participants could select more than one racial affiliation as indicated by a multiracial category (n =18). According to data gathered in the 2011 census (Cabella, Nathan, & Tenenbaum, 2011), the racial ancestry distribution of Uruguay is as follows: African or Black (4.8%), Asian (0.2%), European or White (90.7%), and Native or Indigenous (2.4%). In terms of participants’ training and experience, 46.3% had more than 10 years of
teaching experience, and around half taught at the high school level. Nearly all (90%) had received teacher education targeted at the grade level in which they currently taught.

**Interview participants.** Teachers were invited to participate in interviews through a direct verbal invitation at the National Science Fair and at a professional development course. They were also invited through an invitation (see Appendix D) sent via Facebook messenger to members of a chemistry teacher Facebook page. Twenty-five participants were interviewed; their demographics are summarized in Table 3.2.

Table 3.2 *Interview Participant Demographics by Gender, Professional Degree, and Teaching Experience*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Interview simple percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>Male</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td><strong>Professional degree</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary education chemistry teacher</td>
<td>19</td>
<td>76</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td><strong>Teaching Experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2–5 years</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>6–10 years</td>
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<td>20</td>
</tr>
<tr>
<td>&gt; 10 years</td>
<td>15</td>
<td>60</td>
</tr>
</tbody>
</table>

*Note: N = 25.*

Of all participants interviewed, 76% possessed a secondary school chemistry teacher degree; 24% had a degree in a subject other than chemistry (Table 3.2), such as a BS in biochemistry; primary school teaching; M.Sc. in biological sciences; secondary education natural
science teaching; and master’s degree in education. Over half (56%) of interviewees had earned two or more degrees. In addition, one-third of the teachers taught in middle school, and 23 out of 25 participants were teaching other subjects besides chemistry; additional courses are listed in Table 3.3.

Table 3.3 *Interview results: Participants’ subjects taught outside of chemistry*

<table>
<thead>
<tr>
<th>Field</th>
<th>Subject taught</th>
<th>N</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>Physical Sciences*</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Astronomy</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Physics</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Physical Chemistry</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Microbiology</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Analytical Chemistry</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Applied Science</td>
<td>Food Chemistry</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Applied Chemistry to Agrotechnology</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Technology</td>
<td>Computer Science and Educational</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Technology</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Chemistry Education</td>
<td>Didactics in Chemistry</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Project-based Learning</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

*Note: Physical Sciences include physics and chemistry; this curriculum is delivered during the first and second years of middle school.*
Survey Instrument Design

The survey (see Appendix E) focused on self-efficacy and attitudes toward chemistry along with teachers’ preparation and instructional practices. The survey was conducted online and aggregated using Qualtrics® software.

**Development.** The questionnaire in this study was constructed on the basis of three surveys: Teacher Efficacy and Attitudes Towards STEM Survey (T-STEM) (Friday Institute for Educational Innovation, 2012); Sense of Preparedness (Darling-Hammond, Chung, & Frelow, 2002); and Professional Development Opportunities and Resources (Coalition for Psychology in Schools and Education, 2006). Items from the surveys that were relevant to the target population of this study were included in the instrument. The survey contained four sections: a) demographic information; b) Chemistry Teacher Sense of Preparedness; c) Teacher Efficacy and Attitudes for Teaching Chemistry; and d) Teacher Needs for Teaching Chemistry.

**Section descriptions.** Four sections were included to obtain data on sample demographics, teachers’ preparation to teach chemistry, teachers’ self-efficacy and attitude toward teaching chemistry, and opportunities and challenges to participating in professional development activities. Teachers’ needs in terms of resources for teaching practices were also examined.

**Demographic information.** This section contained 12 questions regarding participants’ gender, ethnicity, current teaching position and grade, years of experience, and school location.

**Chemistry teacher sense of preparedness.** This section was drawn from Darling-Hammond, Chung, and Frelow’s (2002) Sense of Preparedness questionnaire. The original survey contained 39 items, of which 24 were selected for this study given their relevance to the research questions. This section included four constructs: Promote Student Learning (PSL), Understand Learners
(UL), Teach Critical Thinking and Social Development (CTSD), and Use of Technology (UT). All questions consisted of statements scored on a 3-point Likert-type scale (1 = *not well prepared*, 2 = *prepared*, 3 = *well prepared*).

**Teacher self-efficacy and attitudes toward teaching chemistry.** Teacher self-efficacy and attitudes toward teaching chemistry along with use of instructional technology were studied using the T-STEM questionnaire (Friday Institute for Educational Innovation, 2012). Five of the original seven constructs were included in the survey for the current study: Personal Chemistry Teaching Efficacy and Beliefs (PCTEB), Chemistry Teaching Outcome Expectancy Beliefs (CTOEB), Student Technology Use (TechUse), Chemistry Instruction (ChemIns), and Teacher Leadership Attitudes (TLA). Items for each construct were scored on a 5-point Likert-type scale. PCTEB, CTOEB, and TLA were anchored by 1 = *strongly disagree* and 5 = *strongly agree*; TechUse and ChemIns were anchored by 1 = *never* and 5 = *every time*.

**Teacher needs for teaching chemistry.** This section was developed based on the American Psychological Association’s Teacher Needs Survey (Coalition for Psychology in Schools and Education, 2006). Five items from the survey’s Instructional Skills construct were applied to the Professional Development (PD) Needed construct in this study. Additional constructs (e.g., Resources Available and Resources Needed) were developed based on chemistry teachers’ suggestions and an expert panel (see the following section). The final version of the questionnaire in this study included the following constructs: Resources Available (RA), PD Needed (PDN), and Resources Needed (RN). All items were scored on a 5-point Likert-type scale anchored by 1 = *not at all* and 5 = *very*.

**Item selection.** A panel of science educators, science education doctoral students, and chemistry teachers reviewed and refined all items in the four survey sections. The expert panel
consisted of four science education professionals: one experienced Ph.D. in science education; one experienced high school science teacher; one novice Ph.D. in science education; and one experienced high school science teacher and graduate student. Experts reviewed the terms and phrases in the items and provided equivalent terms or phrases based on their experience. Because the study was conducted in a Spanish-speaking country, questionnaires were translated from English into Spanish by a group of specialists (bilingual speakers) and adapted to the cultural context by a group of chemistry teachers who were native Spanish speakers.

**Reliability.** The internal consistency of each section was evaluated using Cronbach’s alpha, with a minimum value of 0.7 considered acceptable (Reynolds, Livingston, & Willson, 2009). Cronbach’s alpha provides a measure of the internal consistency of a test or scale, expressed as a number between 0 and 1. It is usually applied when test items are scored on a Likert-type scale. The reliability of the Teacher Efficacy and Attitudes for Teaching Chemistry section, was $\alpha = 0.801$. The other survey sections demonstrated similarly acceptable reliability (Chemistry Teacher Sense of Preparedness: $\alpha = 0.742$; Teacher Needs for Teaching Chemistry: $\alpha = 0.810$).

**Validity and translation.** To ensure the validity of the instrument in this study, forward and backward translation (Bullinger et al., 1998; Jiménez & Cambronero, 2013; Piñeiro-Albero et al., 2013) and content validity indexing (CVI) (Squires et al., 2013) for cross-cultural validation were used. Because the target population was composed of native Spanish speakers, the translation process consisted of forward/backward translation (verified by two experts) and evaluation of cross-cultural relevance. The translation guidelines included maintaining similar item structure and content as in the original version (English), such that forward translation based on the original items (English to Spanish) was literal with no modifications for cultural consistency (Bullinger et al., 1998; Jiménez & Cambronero, 2013; Piñeiro-Albero et al., 2013).
Backward translation (Spanish to English) was based on the translated Spanish questionnaires. A final review of the translation was completed after forward–backward translation. Two translators (one for forward and another for backward) conducted consecutive translations.

An expert panel cross-cultural review comprised the last step in the translation process for content validity analysis. Cross-cultural validation is a key component of the translation process to ensure accuracy and relevance of a survey to the target population (Beaten, Bombardier, Guillemin, & Bosi-Ferraz, 2000; Ferrer-Peña et al., 2016; Alves, Mota-Sousa, Severino, Sousa, & Caldeira, 2016; Rullán et al., 2015). The CVI (Squires et al., 2013) is used to evaluate the relevance of potential survey questions for inclusion in an instrument. It involves obtaining feedback from five to 10 expert raters who “evaluate if the question is appropriate and relevant to the study's population, if the format of the question is appropriate, and offer suggestions for the improvement” (Squires et al., 2013, p. 268). To capture the perspectives of currently practicing secondary chemistry teachers, experts were selected from the population of secondary school in-service chemistry teachers in Uruguay. This group of experts (n=5) possessed conceptual and content expertise to judge the relevance of questions in terms of chemistry content and pedagogical practices in Uruguay.

A variant of the original CVI methodology involved a review of relevance in terms of the content, construct, and conceptual aspects of the Spanish translation. Experts were asked to analyze construct items in each section of the questionnaire and evaluate whether items were relevant in content, construct, and concept. The review process was conducted via email, and data were processed using Excel®. The first level of expert review was intended to result in an instrument that could produce results reflective of the characteristics of the target population. An experienced bilingual (English–Spanish) researcher and teacher at North Carolina State
University conducted the first-level review by identifying problematic questions, phrases, or terms that would present conceptual difficulties when translated from English to Spanish. This initial review increased the accuracy of items included in the final version of the instrument. At the end of the process, the researcher synthesized experts’ feedback into the three survey sections; as an exception, the Teacher Efficacy and Attitudes for Teaching Chemistry retain edits original structure and conceptual content.

**Pilot study (survey).** A pilot study was conducted to analyze the accuracy and internal consistency of the Spanish version of the Teacher Efficacy and Attitudes for Teaching Chemistry section, which retained its original (English) structure and conceptual content. A sample of 10 in-service chemistry teachers was recruited from the National Science Club Fair in October 2016. All participants agreed to take part in the study and provided written informed consent. Participants received the Teacher Efficacy and Attitudes for Teaching Chemistry section in the Spanish version of the questionnaire. The coefficient of internal consistency for this section was \( \geq 0.70 \) with a Cronbach’s alpha of 0.848 for the entire instrument (Table 3.4). Upon comparison with the results with the original English version for science teachers (i.e., T-STEM), two constructs showed higher internal consistency in the Spanish version (PCTEB and CTOEB), whereas TechUse and TLA were higher in the English version (Table 3.5). All constructs in the Spanish version had a Cronbach's alpha \( \geq 0.70 \).

**Table 3.4 Reliability Data for Teacher Efficacy and Attitudes for Teaching Chemistry Section (Spanish Version)**

<table>
<thead>
<tr>
<th></th>
<th>Number of Items</th>
<th>( \Sigma \text{Var} )</th>
<th>( \text{Var}_T )</th>
<th>Cronbach’s ( \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChemTeach T-STEM Survey</td>
<td>47</td>
<td>57.85</td>
<td>340</td>
<td>0.848</td>
</tr>
</tbody>
</table>
Table 3. 4 (continued)

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Number</th>
<th>Cronbach’s α</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCTEB</td>
<td>11</td>
<td>11.6</td>
<td>72.7</td>
</tr>
<tr>
<td>CTOEB</td>
<td>9</td>
<td>11</td>
<td>58.1</td>
</tr>
<tr>
<td>TechUse</td>
<td>7</td>
<td>9.87</td>
<td>38.5</td>
</tr>
<tr>
<td>ChemIns</td>
<td>14</td>
<td>20.74</td>
<td>154.3</td>
</tr>
<tr>
<td>TLA</td>
<td>6</td>
<td>4.64</td>
<td>16.5</td>
</tr>
</tbody>
</table>

**Note**: Cronbach's alpha values range from 0 to 1. Internal consistency coefficient of ≥ 0.70 is considered acceptable.

1 PCTEB: Chemistry Teaching Efficacy and Beliefs
CTOEB: Chemistry Teaching Outcome Expectancy Beliefs
TechUse: Student Technology Use
ChemIns: Science Instruction
TLA: Teacher Leadership Attitudes.

Table 3. 5 *Reliability Comparison for Teacher Efficacy and Attitudes Towards STEM (T-STEM) (English Version) and Teacher Efficacy and Attitudes for Teaching Chemistry (Spanish Version)*

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Number of Items</th>
<th>Cronbach’s α Chemistry teachers</th>
<th>Cronbach’s α Science teachers*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChemTeach</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-STEMSurvey</td>
<td>47</td>
<td>0.848</td>
<td></td>
</tr>
<tr>
<td>PCTEB</td>
<td>11</td>
<td>0.925</td>
<td>0.908</td>
</tr>
</tbody>
</table>
Table 3.5 (continued)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0.912</td>
<td></td>
<td>0.814</td>
</tr>
<tr>
<td>TechUse</td>
<td>7</td>
<td>0.867</td>
<td></td>
</tr>
<tr>
<td>ChemIns</td>
<td>14</td>
<td>0.932</td>
<td></td>
</tr>
<tr>
<td>TLA</td>
<td>6</td>
<td>0.863</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Cronbach’s alpha values range from 0 to 1. Internal consistency coefficient of ≥ 0.70 is considered acceptable.

* Source: Teacher Efficacy and Attitudes Towards STEM (T-STEM) Development and Psychometric Properties (Friday Institute for Educational Innovation, 2012).

**Interview Protocol Design**

Interviews (see Appendix F) were conducted to gather details that could not be obtained through the online survey. To better understand participants’ perspectives on teaching chemistry, a set of questions was designed to elicit additional information.

**Development.** The purpose of the interview was to understand participants’ preparation to teach chemistry, beliefs, and attitudes toward teaching chemistry, their experiences working with a diverse student population, and perceptions of the teaching evaluation process. Interviews also included questions regarding opportunities for professional development and incorporating technology into educational practices. Questions were based on Patton (2002) interview guidelines to ensure high validity and internal consistency of the instrument. Items were selected to parallel main topics in the survey. A science teacher researcher reviewed the original set of questions and made recommendations for modifications.

**Interview questionnaire.** Interviews involved a semi-structured questionnaire including 34 open-ended questions organized in four sections: a) teacher’s professional background and students background (9 questions); b) general knowledge of teacher preparation and needs (19
questions); c) perceptions of performance evaluation (4 questions); and d) other thoughts (2 questions).

**Item selection.** Interview questions were developed considering the cultural and social context of the population to be interviewed. All original questions were retained except for question #32, in which the term “seniority” was included to specify which grade promotion was being referenced; and question #9, to which another category was added (medium-income homes).

**Reliability and validity.** Teachers’ responses were recorded on paper, transcribed into Excel®, and coded to capture themes in teachers’ self-efficacy about teaching. Codes that emerged in the first and second review cycles (Saldaña, 2010) are described in Table 3.6. Three chemistry teachers reviewed the interview questionnaire to ensure cross-cultural validity and content validity of the instrument.

Table 3.6 **Coding Themes**

<table>
<thead>
<tr>
<th>Categories</th>
<th>Code</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulties with general pedagogy</td>
<td>Learning disabilities</td>
<td>“I have 3 students with curricular [accommodations] for dyslexia and learning difficulties.”</td>
</tr>
<tr>
<td>Use of language and reading comprehension</td>
<td></td>
<td>“[Students] have difficulties in reading and writing, (they cannot read), they do not understand the meaning of words.”</td>
</tr>
<tr>
<td>Student motivation</td>
<td></td>
<td>“I lose students’ interest.”</td>
</tr>
<tr>
<td>Number of students</td>
<td></td>
<td>“The number of students per class, I have 30 students.”</td>
</tr>
<tr>
<td>Difficulties in teaching chemistry</td>
<td>Previous concepts</td>
<td>“There are students with many deficiencies in content knowledge.”</td>
</tr>
</tbody>
</table>
Table 3. 6 (continued)

<table>
<thead>
<tr>
<th>Factors that influence what students learn in chemistry</th>
<th>Abstract thinking</th>
<th>“[Students] have no capacity for abstraction.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous concepts</td>
<td>“[Students] don't have previous concepts such as volume, quantity, etc.”</td>
<td></td>
</tr>
<tr>
<td>Student beliefs</td>
<td>“Preconceptions regarding chemistry … believing that it is difficult.”</td>
<td></td>
</tr>
<tr>
<td>Student interest</td>
<td>“One of the main factors is student interest.”</td>
<td></td>
</tr>
<tr>
<td>Motivation</td>
<td>Teacher</td>
<td>“I think the teacher is the main source of motivation they relate the subject-matter to the teacher and that conditions them if they like it or not.”</td>
</tr>
<tr>
<td>Family</td>
<td>“The family and its socio-cultural environment because they are the ones who tell them why it is important to study.”</td>
<td></td>
</tr>
<tr>
<td>Themselves</td>
<td>“The motivation comes from the student.”</td>
<td></td>
</tr>
<tr>
<td>Instructional difficulties</td>
<td>Institutional constraints</td>
<td>“I cannot change the practices established by Secondary School Board … when the laboratory technician is at the building, the material is under lock.”</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>“Many building difficulties, the rainy days there are places that are flooded.”; “The lab space is not suitable for 30 students in a class.”</td>
<td></td>
</tr>
<tr>
<td>Classroom inspections</td>
<td>Discontent</td>
<td>“It's not the best way of evaluation.”</td>
</tr>
</tbody>
</table>
Table 3. 6 (continued)

<table>
<thead>
<tr>
<th>Evaluation strategies</th>
<th>Process evaluation</th>
<th>“Could be more focused on the evaluation of the process.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated evaluation</td>
<td>“Should be in conjunction between class inspection, evaluation of students, and administrative management.”</td>
<td></td>
</tr>
<tr>
<td>Mentoring</td>
<td>“There should be an accompaniment and tutoring until they consider that you are improving teaching practices.”</td>
<td></td>
</tr>
<tr>
<td>Promotion</td>
<td>Discontent</td>
<td>“Awful, I do not agree.”</td>
</tr>
<tr>
<td>Inequality</td>
<td>“There are teachers who are giving classes [who] have no training but choose first because they rose by seniority, and do not let [in] young teachers with training.”</td>
<td></td>
</tr>
<tr>
<td>Non-recognition</td>
<td>“I have a master’s degree and I could never add it to my merits.”</td>
<td></td>
</tr>
<tr>
<td>Promotion strategies</td>
<td>Opposition and merit</td>
<td>“Should be by merit and theoretical/practical competitions.”</td>
</tr>
<tr>
<td>Integrated evaluation</td>
<td>“Teaching assistance, years of work, continuous training.”</td>
<td></td>
</tr>
<tr>
<td>Support needed</td>
<td>Teamwork</td>
<td>“First support from your peers, better results are obtained working with other teachers.”</td>
</tr>
</tbody>
</table>
Table 3. 6 (continued)

<table>
<thead>
<tr>
<th>Support from administration</th>
<th>“I need support from the administration to facilitate interdisciplinary activities.”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentoring</td>
<td>“We need a tutor who can be a peer, who is more trained in a certain area and who to consult.”</td>
</tr>
<tr>
<td>Training</td>
<td>“What is missing is research in education, some course in teacher training could be included.”</td>
</tr>
<tr>
<td>Resources needed</td>
<td>Materials</td>
</tr>
<tr>
<td></td>
<td>“We need basic materials such as blackboards, adequate bibliography, and comfortable seating for students.”</td>
</tr>
<tr>
<td></td>
<td>Technology</td>
</tr>
<tr>
<td></td>
<td>“We need technological resources such as computer room, internet accessibility, etc. In addition, the resources available in the center as projectors are available for use.”</td>
</tr>
</tbody>
</table>

**Procedure**

**Survey.** Participants received an email invitation with a link to the survey. The survey took 20 minutes to complete with the option to save the survey and continue later. After the first communication two more remainders were sent to participants to complete the survey. The survey was active two weeks.

**Interview.** A personal meeting was arranged with teachers who voluntarily agreed to participate in the interview. Twenty-five teachers where interviewed: 11 at the science fair, 10 at their workplace, and four at places such as coffee shops or libraries. Each interview lasted between 20 and 30 minutes depending on the participant’s provided level of detail. Field notes were recorded during interviews; no audio or video records were collected.
**Data Analysis**

**Survey.** A Wilcoxon rank sum test for Likert-scale data was performed on teachers’ answers regarding the Chemistry Teacher Sense of Preparedness and Teacher Efficacy and Attitudes for Teaching Chemistry survey constructs to determine significant differences between novice and experienced teachers. Significant differences in teachers’ confidence between female and male were also analyzed. An analysis of variance was conducted to identify statistically significant interaction between gender and teaching experience on the instructional technology teachers used most often. Correlations using Spearman’s rank correlation (rho) coefficients were performed to determine relationships between chemistry teachers’ overall sense of preparedness and self-efficacy for teaching chemistry; and to determine the relationship between teachers’ sense of preparedness in technology and how often they used technology while teaching. Professional development and resources needed were also examined. Due to the small proportion of participants in rural schools ($n = 5$), only descriptive statistics were reported for resources and professional development needed questions.

**Interview.** A qualitative analysis was conducted on interview items to identify themes in chemistry teachers’ responses. Responses were clustered to determine frequencies and percentages with regard to the codes in Table 3. For example, one participant explained,

> The main factors I think influence what students learn in chemistry are previous concepts acquired, basic notions such as the concept of volume or quantity that they should have learned in previous courses but they do not know. The students do not have the ability for abstract thoughts.

This statement was coded for ‘abstract thinking’ and ‘previous concepts’. Responses that did not meet this pattern were re-categorized and included in the results section as written answers. A second science education researcher (in addition to the author) coded ten teachers’ responses, and the inter-rater agreement was 82%.
Limitations of the Study

Results of this study are limited to responses from teachers who participated in the survey and/or interview. The recruitment process and accessibility to teachers’ contact information were the main challenges in the present work. Contact information was unavailable through either the institutions responsible for training teachers or the Secondary Education Council, which oversees secondary education administration. One drawback when conducting the survey was that people in Uruguay are not accustomed to answering online surveys. Surveys are not commonly used on a large scale in Uruguay with the exception of the national census every 10 years, for which data are gathered in person. Participant distribution for the survey included 17 of 19 provinces in Uruguay; however, the surveyed teachers may or may not be representative of province demographics. No record is available of the total number of chemistry teachers in each province.

As a data collection tool, interviews present methodological limitations when performed in person. Although one limitation of qualitative studies is that the researcher’s presence may result in biased participant responses (Creswell, 2014), participants in this study were assured of the confidentiality of their answers and were not audio recorded during interviews; these steps hopefully enabled participants to freely express their opinions and perceptions beyond the content of the questions (as a cultural issue people in Uruguay feel uncomfortable if they know they are recorded during an interview).
CHAPTER 4: Results

This chapter presents the results of the survey and interviews conducted with chemistry teachers who participated in the study. Findings are presented for each research question. In each section, quantitative data analysis (i.e., for survey items) is introduced to identify participants’ perceived degree of preparedness for teaching chemistry, their attitudes and self-efficacy toward their instructional practices, and their perceived ability to promote student learning. The analyses also address teachers’ use of technology and teachers’ needs related to resources and professional development opportunities. The relationships among teachers’ gender, experience, school location, and instructional practices are also evaluated. Then, qualitative data (i.e., from interviews) are presented to provide additional context for the challenges teachers reported that they face at the classroom level (e.g., when teaching students with learning disabilities and working with a heterogeneous student population) and the institutional level. Teachers’ perceptions of the evaluation of their performance and available degree promotion mechanisms are also discussed.

Teacher Preparation

Survey results. Regarding RQ1 ("What preparation do chemistry teachers in Uruguay receive to prepare them to teach?") , participants’ responses regarding whether they felt prepared to promote student learning revealed that teachers felt prepared on all items analyzed. However, a high percentage of teachers felt they were not well prepared (20.4%) to teach in ways where their instruction enabled students to learn (Table 4. 1). One-third did not feel prepared to help students achieve high academic standards (30.2%) or to develop a curriculum that builds on students’ experiences, interests, and abilities (30%). About a quarter of teachers surveyed felt well prepared to teach their subject area effectively and to use instructional strategies that
promote active student learning (25%). One out of five felt well prepared to evaluate curriculum materials for their usefulness and appropriateness for students (19%); design effective hands-on chemistry techniques (19%); use a variety of assessments (e.g., observations, portfolios, test performance tasks, and anecdotal records) to determine students’ strengths, needs, and programs (20%); and present a discipline-based or interdisciplinary curriculum to students (19%). Only 14% of teachers surveyed felt well prepared to set challenging expectations related to students’ learning and performance.

Table 4.1 *Survey results: Chemistry teachers’ reported preparedness*

<table>
<thead>
<tr>
<th>Construct</th>
<th>Not well prepared</th>
<th>Prepared</th>
<th>Well prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency (percent)</td>
<td>Frequency (percent)</td>
<td>Frequency (percent)</td>
</tr>
<tr>
<td>Promote student learning (<em>n</em> = 98)</td>
<td>20 (20.4)</td>
<td>59 (60.2)</td>
<td>19 (19.4)</td>
</tr>
<tr>
<td>Promote critical thinking and social skills (<em>n</em> = 97)</td>
<td>14 (14.4)</td>
<td>62 (64)</td>
<td>21 (21.6)</td>
</tr>
<tr>
<td>Understand learners (<em>n</em> = 97)</td>
<td>32 (33)</td>
<td>43 (44.3)</td>
<td>22 (22.7)</td>
</tr>
<tr>
<td>Use of technology (<em>n</em> = 95)</td>
<td>17 (17.9)</td>
<td>57 (60)</td>
<td>21 (22.1)</td>
</tr>
<tr>
<td>Overall, how well prepared do you feel to teach chemistry? (<em>n</em> = 96)</td>
<td>7 (7.3)</td>
<td>64 (66.7)</td>
<td>25 (26)</td>
</tr>
</tbody>
</table>

*Note: n = number of participants (not all teachers responded to all items). Responses ranged from 1 (not well prepared) to 3 (well prepared).*
When teachers were asked if they felt prepared to promote critical thinking and social skills among their students, one out of five teachers answered they felt well prepared to encourage students to develop questioning and discussion skills (18.6%) and to help students think critically and solve problems (22.7%). A quarter of teachers surveyed (24.7%) felt well prepared to encourage their students to identify, question, and understand ideas from diverse perspectives.

In addition, teachers were asked if they felt capable of identifying students’ learning needs. One out of five answered they felt well prepared to assess students’ strengths and needs (20%), but only 13% indicated feeling well prepared to understand how students in their classroom were learning. About a quarter of teachers reportedly felt well prepared to understand how students’ learning is influenced by their social, emotional, physical, and cognitive development (26%) and their family and cultural background (27%). Conversely, when analyzed by teaching experience, roughly half of novice and experienced teachers felt underprepared to identify and address students’ learning needs and difficulties (54.6% and 43.8%, respectively).

To determine significant differences between novice and experienced teachers in perceived preparation, a Wilcoxon rank sum test for Likert-type scale data was performed. Findings revealed significant differences between novice and experienced teachers in feeling prepared to promote student learning ($W = 739, p = 0.007$) and to use technology during instruction ($W = 817.5, p = 0.03$). Experienced teachers felt either prepared or well prepared to “teach subject matter concepts, knowledge, and skills in ways that enable students to learn” (97%), “create disciplinary-based and interdisciplinary curriculum” (75%), and “design more effective hands-on chemistry techniques” (80%). Regarding technology use, experienced teachers reported feeling better prepared to use technology to support research and analysis
(82%) than novice teachers (45%). No significant differences were found between novice and experienced teachers’ median responses regarding how well prepared they felt to develop students’ critical thinking and social skills ($W = 937.5, p = 0.19$) or to understand learners ($W = 903, p = 0.13$).

Spearman’s rank correlation (rho) analysis was employed to further investigate the relationship between chemistry teachers’ overall sense of preparedness and self-efficacy for teaching chemistry. Results indicated a significant correlation between teachers’ overall sense of preparedness ($n = 96, M = 2.19$) and survey items describing respondents’ self-efficacy, specifically their ability to teach chemistry (Table 4.2). Teachers who felt better prepared overall strongly believed they could teach chemistry effectively, understand science concepts sufficiently well, welcome and answer questions, increase student interest in chemistry, and help students understand chemistry concepts ($p < .01$). Teachers also reported that they felt confidence that they are continually improving their chemistry teaching practice ($p = 0.05$).

Table 4.2 Survey results: Spearman’s rho correlation between teachers’ reported overall preparedness and teachers’ self-efficacy in teaching chemistry

<table>
<thead>
<tr>
<th>Item</th>
<th>Correlation coefficient ($r_s$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am confident that I can answer students’ chemistry questions.</td>
<td>0.45**</td>
</tr>
<tr>
<td>I know the steps necessary to teach chemistry effectively.</td>
<td>0.35**</td>
</tr>
<tr>
<td>I am confident that I can teach chemistry effectively.</td>
<td>0.44**</td>
</tr>
<tr>
<td>I understand science concepts well enough to be effective in teaching chemistry.</td>
<td>0.44**</td>
</tr>
</tbody>
</table>
Table 4. 2 (continued)

| When a student has difficulty understanding a chemistry concept, I am confident that I know how to help the student understand it better. | 0.41** |
| When teaching chemistry, I am confident enough to welcome student questions. | 0.42** |
| I know what to do to increase student interest in chemistry. | 0.32** |
| I am continually improving my chemistry teaching practice. | 0.20* |
| I would invite a colleague to evaluate my chemistry teaching. | 0.19 |
| I am confident that I can explain to chemistry why science experiments work. | 0.18 |

*Note: Correlation is significant at *p < .05, **p < .01.

Conversely, no significant relationship was found between teachers’ overall sense of preparation and their confidence to explain why science experiments work from a chemistry perspective (r = 0.184, p = 0.072). In other words, that teachers feel prepared in general to teach chemistry does not mean that they are able to explain the chemistry behind science experiments. Similar results were found regarding whether teachers would invite a colleague to evaluate their chemistry teaching (r = 0.193, p = 0.061).
Interview results. Interviews were conducted with a sample of 25 participants to better understand teachers’ perceptions of whether their preparation provided them with specific pedagogical tools to teach chemistry and incorporate technology into their instruction. Teachers were also asked to explain why they did or did not feel prepared to teach a heterogeneous student population, including students with learning disabilities. Interview questions were designed to acquire a deeper understanding of the survey data. To obtain more information about teachers’ preparation, participants were asked to state how many chemistry courses they took during their training. Nearly three-quarters of teachers (72%) answered that they had taken more than 10 chemistry courses during their 4-year preparation.

To investigate teachers’ perceptions of their preparation in terms of pedagogical tools to teach chemistry, 60% of interviewed teachers answered they did not believe that their preparation had provided them pedagogical tools; rather, participants reported having acquired pedagogical tools through experience, extracurricular courses, or independent learning. Moreover, 76% of teachers felt their preparation did not provide the tools necessary to incorporate technology into their instructional practices. By contrast, teachers stated they felt prepared to teach science process skills (72%) and to teach students the nature of science (82%). Most (83%) teachers felt prepared to teach laboratory concepts, and nearly all (96%) felt prepared to teach laboratory safety.

Teachers were also asked to describe which pedagogical tools were most effective when teaching chemistry. Participants’ answers highlighted that problem and project-based learning (PBL), experimental activities, technological resources (e.g., videos or 3D animations), game-based learning (e.g., Kahoot©), and teamwork were the most effective tools for teaching chemistry. One teacher remarked, “The best [tools] that I use to teach chemistry concepts to
students are the experimental activities that allow them to experiment, make mistakes and try again.”

To explore teachers’ preparation to use technology, participants were asked if they felt their training had provided tools for integrating technology into their instructional practices and if they had taken professional development courses focused on using technology. Slightly more than three-quarters (76%) of interviewed teachers had taken an extracurricular course about using technological tools in the classroom to teach chemistry. Of those who reported not taking any such course ($n = 6$), half of the teachers ($n = 3$) responded they had learned how to use relevant technology on their own.

When participants were asked if they felt prepared to teach students with learning disabilities, 84% reported not feeling prepared. Teachers claimed that during their training, the institute did not give them relevant tools because preparation was mainly focused on content knowledge. For example, one teacher stated, “No, not at all. [The institute] did not give us the tools to teach students with learning disabilities.” Another teacher went further in saying, “There should be courses on that ‘subject’ during teacher training. The problems we face are many and varied. I did courses on sign language for deaf students, but we need a multidisciplinary team in the institutions to support teachers.”

In a related vein, participants were asked if they felt prepared to teach a heterogeneous student population. Their consensus was overwhelming: none responded that their training had provided them with the tools to teach this population. On the contrary, the teachers argued that using their experience and testing strategies through trial and error afforded them the tools they needed. One teacher shared, “Yes, I feel prepared, but because I work hard every day to improve
my teaching practices to deal with a diverse population of students. The best way to work is to vary the activities for different topics.” Another teacher said,

My preparation did not give me the tools to teach a diverse population of students. … To a certain extent, my experience as a teacher gave me the opportunity to try different ways of working with the students in the classroom. Most of the time, I try to find activities to draw the students’ attention.

**Teacher Self-Efficacy and Attitudes Toward Teaching Chemistry**

**Survey results.** In terms of RQ2 (“What is the state of chemistry teachers’ self-efficacy and attitudes toward teaching chemistry?”), teachers were asked about their confidence related to their efficacy beliefs around teaching, their teaching outcome expectancy, and their attitude toward teacher leadership, Table 4.3 summarize participants’ responses.

Table 4.3 *Survey descriptive statistics: Teachers’ reported teaching efficacy and beliefs, outcome expectancy, and teacher leadership attitudes*

<table>
<thead>
<tr>
<th>Construct</th>
<th>N</th>
<th>Mdn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Efficacy and Beliefs</td>
<td>111</td>
<td>4</td>
</tr>
<tr>
<td>Outcome Expectancy</td>
<td>106</td>
<td>3</td>
</tr>
<tr>
<td>Teacher Leadership Attitudes</td>
<td>101</td>
<td>5</td>
</tr>
</tbody>
</table>

*Note: N = number of participants; Mdn = median. Likert-type scale: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree.*

Most respondents selected “agree” when asked if they felt confident to teach chemistry (*Mdn = 4*) and “strongly agree” when asked if they believe that teachers should have a leadership attitude (*Mdn = 5*). Teachers were highly confident in their ability to teach chemistry effectively (81%). Similar proportions stated they were confident they had the necessary skills to teach chemistry
(92.7%) and that they understood chemistry concepts well enough to teach chemistry effectively (90.1%). Teachers also felt confident fielding students’ questions (89.2%) and answering chemistry-related questions (92%). Respondents also shared they were confident they knew how to help students understand chemistry concepts (93.6%) along with knowing what to do to increase student interest in chemistry (63.6%). In addition, 91% of teachers responded that they would invite a colleague to evaluate their chemistry teaching. Participants’ responses are summarized in Table 4.4.

Table 4.4 Survey results: Teachers’ reported teaching efficacy and beliefs

<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly disagree Frequency (percent)</th>
<th>Disagree Frequency (percent)</th>
<th>Neither agree nor disagree Frequency (percent)</th>
<th>Agree Frequency (percent)</th>
<th>Strongly agree Frequency (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am continually improving my chemistry teaching practice.</td>
<td>2 (1.8)</td>
<td>-</td>
<td>10 (9.0)</td>
<td>55 (49.6)</td>
<td>44 (39.6)</td>
</tr>
<tr>
<td>2. I know the steps necessary to teach chemistry effectively.</td>
<td>1 (0.9)</td>
<td>3 (2.7)</td>
<td>29 (26.1)</td>
<td>60 (54.0)</td>
<td>18 (16.2)</td>
</tr>
<tr>
<td>3. I am confident that I can explain to chemistry why science experiments work.</td>
<td>2 (1.8)</td>
<td>2 (1.8)</td>
<td>29 (26.1)</td>
<td>55 (49.6)</td>
<td>23 (20.7)</td>
</tr>
<tr>
<td>4. I am confident that I can teach chemistry effectively.</td>
<td>1 (0.9)</td>
<td>2 (1.8)</td>
<td>18 (16.4)</td>
<td>64 (58.2)</td>
<td>25 (22.7)</td>
</tr>
<tr>
<td>5. I am confident I have the necessary skills to teach chemistry.</td>
<td>-</td>
<td>1 (0.9)</td>
<td>7 (6.4)</td>
<td>76 (69.1)</td>
<td>26 (23.6)</td>
</tr>
<tr>
<td>6. I understand science concepts well enough to be effective in teaching chemistry.</td>
<td>-</td>
<td>1 (0.9)</td>
<td>10 (9.0)</td>
<td>77 (69.4)</td>
<td>23 (20.7)</td>
</tr>
</tbody>
</table>
Table 4. 4 (continued)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>7. I would invite a colleague to evaluate my chemistry teaching.</td>
<td></td>
<td>1 (0.9)</td>
<td>9 (8.3)</td>
<td>48 (44)</td>
</tr>
<tr>
<td>8. I am confident that I can answer students’ chemistry questions.</td>
<td></td>
<td>2 (1.8)</td>
<td>10 (9.0)</td>
<td>71 (64)</td>
</tr>
<tr>
<td>9. When a student has difficulty understanding a chemistry concept, I am confident that I know how to help the student understand it better.</td>
<td></td>
<td></td>
<td>7 (6.4)</td>
<td>68 (61.8)</td>
</tr>
<tr>
<td>10. When teaching chemistry, I am confident enough to welcome student questions.</td>
<td></td>
<td>1 (1.9)</td>
<td>8 (7.3)</td>
<td>68 (62.4)</td>
</tr>
<tr>
<td>11. I know what to do to increase student interest in chemistry.</td>
<td></td>
<td>9 (8.2)</td>
<td>31 (28.2)</td>
<td>50 (45.5)</td>
</tr>
</tbody>
</table>

Note: n = 111.

A Wilcoxon rank sum test was performed to identify significant differences in responses by gender, revealing no significant effect of gender (W = 752.5, p = 0.147) on participants’ confidence to teach chemistry effectively. Fewer females believed they could teach chemistry effectively (78%) and felt confident explaining why science experiments work (66%) compared with males (95% and 90%, respectively).

Upon comparing novice and experienced teachers’ responses, the same trends emerged as in the entire sample (i.e., responses of “agree” and “strongly agree” exceeded 60%). However, the extent of agreement among experienced teachers was slightly higher than that among novices on all statements. The percentages of novice teachers who felt confident they knew the steps necessary to teach chemistry effectively was 54%, those who could explain why science
experiments work was 63%, and those who had the necessary skills to teach chemistry was 83%, while for experienced teachers the results were 90% in all the above statements. A Wilcoxon rank sum test was performed to compare novice and experienced teachers’ self-efficacy for teaching chemistry. Results indicated no significant differences between novice and experienced teachers ($W = 1098.5$, $p = 0.113$).

When asked if they felt confident that student learning could be influenced through their teaching, most respondents chose “neither agree nor disagree” for the statements ($Mdn= 3$). Yet many teachers responded “agree” or “strongly agree” to the statements “The inadequacy of a student’s chemistry background can be overcome by good teaching” (77%), “The teacher is generally responsible for students’ learning in chemistry” (58%), “When a low achieving child progresses more than expected in chemistry, it is usually due to extra attention given by the teacher” (70%), and “If the student is showing more interest in chemistry at school, it is probably due to the performance of the teacher” (53%). Teachers’ responses are summarized in Table 4.

Table 4. 5 Survey results: Teachers’ self-confidence in their ability to influence student learning through their teaching

<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly disagree Frequency (percent)</th>
<th>Disagree Frequency (percent)</th>
<th>Neither agree nor disagree Frequency (percent)</th>
<th>Agree Frequency (percent)</th>
<th>Strongly agree Frequency (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. When a student does better than usual in chemistry, it is often because the teacher exerted a little extra effort.</td>
<td>2 (1.89)</td>
<td>20 (18.87)</td>
<td>60 (56.60)</td>
<td>17 (16.04)</td>
<td>7 (6.60)</td>
</tr>
</tbody>
</table>
Table 4.5 (continued)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2. The inadequacy of a student’s chemistry background can be overcome by good teaching.</td>
<td>-</td>
<td>3 (2.86)</td>
<td>21 (20.00)</td>
<td>55 (52.38)</td>
</tr>
<tr>
<td>3. When a student’s learning in chemistry is greater than expected, it is most often due to their teacher having found a more effective teaching approach.</td>
<td>1 (0.95)</td>
<td>12 (11.43)</td>
<td>49 (46.67)</td>
<td>34 (32.39)</td>
</tr>
<tr>
<td>4. The teacher is generally responsible for students’ learning in chemistry.</td>
<td>2 (1.89)</td>
<td>12 (11.32)</td>
<td>31 (29.26)</td>
<td>49 (46.23)</td>
</tr>
<tr>
<td>5. If students’ learning in chemistry is less than expected, it is most likely due to ineffective chemistry teaching.</td>
<td>4 (3.77)</td>
<td>27 (25.44)</td>
<td>46 (43.40)</td>
<td>24 (22.64)</td>
</tr>
<tr>
<td>6. Students’ learning in chemistry is directly related to their teacher’s effectiveness in chemistry teaching.</td>
<td>1 (0.94)</td>
<td>22 (20.75)</td>
<td>45 (42.45)</td>
<td>35 (33.02)</td>
</tr>
<tr>
<td>7. When a low achieving child progresses more than expected in chemistry, it is usually due to the extra attention given by the teacher.</td>
<td>-</td>
<td>8 (7.55)</td>
<td>24 (22.64)</td>
<td>63 (59.43)</td>
</tr>
<tr>
<td>8. If the student is showing more interest in chemistry at school, it is probably due to the performance of the teacher.</td>
<td>-</td>
<td>10 (9.43)</td>
<td>40 (37.74)</td>
<td>48 (45.28)</td>
</tr>
</tbody>
</table>
Table 4. 5 (continued)

| 9. Minimal student learning in chemistry can generally be attributed to their teachers. | 4 (3.77) | 34 (32.08) | 49 (46.23) | 17 (16.04) | 8 (1.89) |

*Note: n = 106.*

When differentiating on the basis of teaching experience, novice teachers’ (*Mdn = 3*) and experienced teachers’ (*Mdn = 3*) responses were similar to the median of the sample population. On average, participants answered “neither agree nor disagree” to all statements, even though substantial disagreement was identified between novice and experienced teachers. Generally, 10% or more of respondents chose either “disagree” or “strongly disagree” on these statements. The highest percentages of negative responses among novice and experienced teachers (Table 4. 6) were associated with the statements “If students’ learning in chemistry is less than expected, it is most likely due to ineffective chemistry teaching” (34% of novice and 26% of experienced teachers) and “Students’ learning in chemistry is directly related to their teacher’s effectiveness in chemistry teaching” (20% of novice and 23% of experienced teachers). Both novice and experienced teachers were not confident that extra effort in their teaching practices would elicit better student performance (51% of novice and 60% of experienced teachers) or that effective teaching approaches would lead to greater student learning than expected (45% of novice and 46% of experienced teachers). Thus, a notable proportion of teachers believed that student learning was not attributable to instructors’ personal effectiveness in teaching chemistry, such that neither additional effort nor more effective teaching practices would lead to better student performance.
Table 4. 6 Survey results: Percentage “strongly disagree”/“disagree” in teachers’ response about self-confidence in their ability to influence student learning through their teaching practices

<table>
<thead>
<tr>
<th>Item</th>
<th>Novice</th>
<th>Experienced</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. When a student does better than usual in chemistry, it is often because the teacher exerted a little extra effort.</td>
<td>51</td>
<td>60</td>
</tr>
<tr>
<td>3. When a student’s learning in chemistry is greater than expected, it is most often due to their teacher having found a more effective teaching approach.</td>
<td>45</td>
<td>46</td>
</tr>
<tr>
<td>5. If students’ learning in chemistry is less than expected, it is most likely due to ineffective chemistry teaching.</td>
<td>34</td>
<td>26</td>
</tr>
<tr>
<td>6. Students’ learning in chemistry is directly related to their teacher’s effectiveness in chemistry teaching.</td>
<td>20</td>
<td>23</td>
</tr>
</tbody>
</table>

Note: n = 106.

When teachers were asked if student learning was generally the instructor’s responsibility, 20% of novice teachers did not agree with this statement, whereas 67% of experienced teachers selected either “agree” or “strongly agree.” Moreover, when asked if minimal student learning in chemistry could generally be attributed to teachers, 60% of novice teachers selected “neither agree nor disagree”, and 41% of experienced teachers selected “disagree” or “strongly disagree”, collectively. The Wilcoxon rank sum test indicated no significant differences between novice and experienced teachers in their beliefs that teachers can influence student learning ($W = 1229, p = 0.748$).
Chemistry Teachers’ Instructional Practices

Survey results. Regarding RQ3 (“What instructional practices do chemistry teachers use?”), teachers were asked how often their students engaged in different tasks. Responses ranged from 1 (never) to 5 (every time). Findings showed that teachers used certain instructional practices “about half the time” (Mdn = 3). However, more than 40% of teachers surveyed responded either “never” or “occasionally” to tasks including recognizing patterns in data (46%), making and testing predictions (58%), developing students’ problem-solving skills through investigations (66%), engaging students in content-driven dialogue (40%), critiquing others’ reasoning (40%), and learning about careers related to instructional content (60%), Table 4. 7 summarizes participants’ responses.

Table 4. 7 Survey results: Frequency of chemistry teachers’ use of instructional practices to teach chemistry

<table>
<thead>
<tr>
<th>Item</th>
<th>Never</th>
<th>Occasionally</th>
<th>About half the time</th>
<th>Usually</th>
<th>Every time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop problem-solving skills through investigations (e.g. scientific, design or theoretical investigations).</td>
<td>15</td>
<td>51</td>
<td>18</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>2. Work in small groups.</td>
<td>-</td>
<td>9</td>
<td>19</td>
<td>52</td>
<td>20</td>
</tr>
<tr>
<td>3. Make predictions that can be tested.</td>
<td>12</td>
<td>46</td>
<td>17</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>4. Make observations or measurements</td>
<td>-</td>
<td>22</td>
<td>15</td>
<td>52</td>
<td>8</td>
</tr>
<tr>
<td>5. Use tools to gather data (e.g. calculators, computers, computer programs, scales, measurements units etc.).</td>
<td>20</td>
<td>12</td>
<td>12</td>
<td>38</td>
<td>17</td>
</tr>
</tbody>
</table>
Table 4.7 (continued)

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>6. Recognize patterns in data.</td>
<td>9</td>
<td>37</td>
<td>20</td>
<td>31</td>
<td>3</td>
</tr>
<tr>
<td>7. Create reasonable explanations of results of an experiment or investigation.</td>
<td>-</td>
<td>32</td>
<td>29</td>
<td>33</td>
<td>6</td>
</tr>
<tr>
<td>8. Choose the most appropriate methods to express results (e.g. drawings, models, charts, graphs, technical language, etc.).</td>
<td>2</td>
<td>27</td>
<td>28</td>
<td>37</td>
<td>6</td>
</tr>
<tr>
<td>9. Implement activities with a real-world context.</td>
<td>8</td>
<td>27</td>
<td>17</td>
<td>35</td>
<td>13</td>
</tr>
<tr>
<td>10. Engage in content-driven dialogue.</td>
<td>-</td>
<td>40</td>
<td>26</td>
<td>28</td>
<td>6</td>
</tr>
<tr>
<td>11. Reason abstractly.</td>
<td>-</td>
<td>37</td>
<td>34</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>12. Reason quantitatively.</td>
<td>-</td>
<td>26</td>
<td>39</td>
<td>33</td>
<td>2</td>
</tr>
<tr>
<td>13. Critique the reasoning of others.</td>
<td>-</td>
<td>40</td>
<td>27</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>14. Learn about careers related to the instructional content.</td>
<td>11</td>
<td>49</td>
<td>13</td>
<td>20</td>
<td>7</td>
</tr>
</tbody>
</table>

*Note: n = 100.*

Experienced teachers exhibited the same tendencies as the overall sample (*Md* = 3), whereas novice teachers responded “occasionally” to most statements (*Md* = 2). Only 3% of novice teachers responded “every time” to items related to cultivating students’ problem-solving skills, making predictions that can be tested, and organizing debate activities to encourage criticism of others’ reasoning. In addition, more than 50% of novice and experienced teachers answered “usually” or “every time” when asked about completing instruction tasks such as...
small-group work (72%), making observations or taking measurements (53% and 65%, respectively), and using tools to gather data (60% and 72%, respectively). A Wilcoxon rank sum test was conducted to identify significant differences between novice and experienced teachers’ instructional practices; results showed no significant difference in the frequency with which novice and experienced teachers employed certain teaching practices, \( W = 942, p = 0.156 \).

When teachers were asked how often their students used technology during class time, most reported that students used technology “occasionally” \( (Mdn = 2) \). Teachers responded that students used technology such as data visualization, research, and communication tools “occasionally” (44.6%) during their instruction (Table 4.8). Teachers also responded that their students either “never” or “occasionally” used the same kinds of tools that professional researchers used, such as simulations, databases, and laboratory equipment (76.7%). Students reportedly either “never” or “occasionally” worked on technology-supported projects that addressed technology applications in the real world (63%) or used technology to support higher-order thinking (e.g., analysis, synthesis, and evaluation of ideas and information) (68%). Additionally, teachers reported that students either “never” or “occasionally” used technology to create new ideas and representations of information (52%) and to solve problems (52%). Conversely, teachers responded that students used technology “usually” or “every time” to access online resources and information as part of activities (67%) and to communicate and collaborate with others outside the classroom (57%).
Table 4. 8 Survey results: Frequency and percentage of chemistry teachers’ use of instructional technology to teach chemistry

<table>
<thead>
<tr>
<th>Item</th>
<th>Never</th>
<th>Occasionally</th>
<th>About half the time</th>
<th>Usually</th>
<th>Every time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Use a variety of technologies, e.g. productivity, data visualization, research, and communication tools.</td>
<td>-</td>
<td>46 (44.7)</td>
<td>11 (10.7)</td>
<td>37 (36)</td>
<td>9 (8.7)</td>
</tr>
<tr>
<td>2. Use technology to communicate and collaborate with others, beyond the classroom.</td>
<td>2 (1.9)</td>
<td>31 (30.1)</td>
<td>13 (12.6)</td>
<td>47 (45.6)</td>
<td>10 (9.7)</td>
</tr>
<tr>
<td>3. Use technology to access online resources and information as a part of activities.</td>
<td>-</td>
<td>24 (23.3)</td>
<td>12 (11.7)</td>
<td>54 (52.4)</td>
<td>13 (12.6)</td>
</tr>
<tr>
<td>4. Use the same kinds of tools that professional researchers use, e.g. simulations, databases, laboratory equipment.</td>
<td>35 (34)</td>
<td>44 (42.7)</td>
<td>7 (6.8)</td>
<td>14 (13.6)</td>
<td>3 (2.9)</td>
</tr>
<tr>
<td>5. Use technology to help solve problems.</td>
<td>13 (12.6)</td>
<td>39 (37.9)</td>
<td>16 (15.5)</td>
<td>28 (27.2)</td>
<td>7 (6.8)</td>
</tr>
<tr>
<td>6. Use technology to support higher-order thinking, e.g. analysis, synthesis, and evaluation of ideas and information.</td>
<td>20 (19.4)</td>
<td>50 (48.5)</td>
<td>7 (6.8)</td>
<td>22 (21.4)</td>
<td>4 (3.9)</td>
</tr>
<tr>
<td>7. They work on technology-supported projects that address the applications of technology in the real world.</td>
<td>26 (25.2)</td>
<td>39 (37.9)</td>
<td>11 (10.7)</td>
<td>20 (19.4)</td>
<td>7 (6.8)</td>
</tr>
<tr>
<td>7. Use technology to create new ideas and representations of information.</td>
<td>13 (12.6)</td>
<td>39 (37.9)</td>
<td>16 (15.5)</td>
<td>28 (27.2)</td>
<td>7 (6.8)</td>
</tr>
</tbody>
</table>

*Note: n = 103.*
To determine the effects of gender and teaching experience on how often chemistry teachers used technology during instruction, a two-way analysis of variance was conducted (Table 4.9). Results revealed a statistically significant interaction between gender and teaching experience on the instructional technology teachers used more often, $F(1, 101) = 5.20, p = 0.025$. However, no statistically significant differences emerged between teaching experience, $F(1, 101) = 2.40, p = 0.124$, and gender, $F(1, 101) = 3.20, p = 0.077$.

Table 4.9 Survey results: Two-way analysis of variance (ANOVA) between instructional technology chemistry teachers use in general by gender and experience

<table>
<thead>
<tr>
<th>Instructional technology</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>1</td>
<td>2.24</td>
<td>2.243</td>
<td>3.20</td>
<td>0.077</td>
</tr>
<tr>
<td>Experience</td>
<td>1</td>
<td>1.69</td>
<td>1.686</td>
<td>2.40</td>
<td>0.124</td>
</tr>
<tr>
<td>Gender × Experience</td>
<td>1</td>
<td>3.65</td>
<td>3.652</td>
<td>5.20</td>
<td>0.025*</td>
</tr>
<tr>
<td>Residual</td>
<td>101</td>
<td>70.90</td>
<td>0.702</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: SS = sum of squares; MS = mean square; df = degrees of freedom. Significant at *$p < 0.05$. |

A Spearman rho correlation was conducted to determine if a correlation existed between chemistry teachers’ sense of preparedness to use technology and how often they actually used technology during instruction. Results indicated no correlation between the two variables, $r_s$ = 0.060, $p = 0.563$.

**Teaching Chemistry: Challenges**

To obtain a clearer understanding of the challenges teachers face in the classroom, teachers were asked about the main problems they faced when teaching a heterogeneous student
population. Through interviews, five themes emerged in teachers’ responses: learning disabilities, use of language and reading comprehension, student motivation, number of students in the class, and previous knowledge. Teachers identified previous knowledge as the primary problem (32% of respondents), followed by learning disabilities and student motivation (28%) and the number of students in the classroom and use of language and reading comprehension (24%). For example, one teacher said,

There is a gap between the previous knowledge and the skills that students bring to the class. They also have difficulties in reading comprehension. On the other hand, there is great disinterest [among] the students. Not all of them have study habits or social behavior. Many have difficulties that have not been diagnosed, [such] as learning or behavioral [difficulties]. As teachers we realize that they have some problems, but we do not know how to give a diagnosis. The great diversity in the level of the students makes the good ones undervalued [while misbehaving] students [disturb] the rest of the students who want or [are trying] to learn.

Teachers were also asked about which factors they thought influenced what students learned in chemistry. Teachers responses were coded into four categories: abstract thinking (i.e., students can think about processes and mechanisms using metaphors or representations); previous concepts (i.e., concepts mainly related to chemistry or mathematics); students’ beliefs (i.e., beliefs that chemistry is a difficult subject); and student interest (i.e., interest in the subject or in school). Some teachers’ responses fell into more than one category. Of all teachers interviewed ($N = 25$), 28% ($n = 7$) identified abstract thinking, previous concepts, and student interest as the main factors, whereas 16% ($n = 4$) identified student beliefs as the main factor influencing what students learned in chemistry. Three teachers’ answers were off-topic, and three other teachers offered reasons outside the identified categories.

To explore teachers’ perceptions of student motivation, participants were asked if they thought the teacher is the main source of motivation in promoting student learning. Teachers
identified themselves as the main source of motivation, and two other categories emerged: family (i.e., household support) and self-motivation (i.e., students’ intrinsic motivation). Eighteen teachers (72%) identified the teacher as the main source of motivation, seven (28%) identified the family as the main source, and five (20%) identified students’ self-motivation as the main driver behind student learning. Teachers’ responses could include more than one category.

Teachers were also asked about the main difficulties they faced in teaching. Most teachers (56%) indicated that institutional constraints and infrastructure (44%) posed major challenges. For example, one teacher explained,

There is a gap between public and private schools, from the most basic [things] such as markers and blackboard erasers, to books and teaching material for the subject. In addition, the physical space is not pleasant. There are no curtains that [block] the sun and in summer, the students and the teacher die of heat. There are institutional rules that also affect [teachers]. It matters more to comply with the rules than the teacher–student relationship. For example, you start the class by asking [students] to take off their hats before saying good morning.

Another teacher stated, “There is no support from the administration of the school [in general] to the teachers, and the bureaucracy of the institution does not allow you to use technological resources such as projectors or computers for your class.”

**Performance Evaluation and Promotion**

To explore teachers’ perceptions of performance evaluations, participants were asked through the interview if they thought the actual evaluation, based on a one-time visit from an inspector, was the best way to evaluate chemistry instruction. Responses were coded into three categories: discontent, non-continuous evaluation, and lack of personnel. Eighty-four percent of teachers interviewed were dissatisfied with the evaluation method, and 28% contended that evaluation was not continuous—in the best case, teachers were visited once throughout their teaching career. In addition, 20% of teachers answered that the lack of personnel was one reason
why an inspector had not visited their classes. One teacher noted, “I am dissatisfied with the form of teacher evaluation. There is a lack of personnel to evaluate, only two inspectors for the whole country. I have not been visited by an inspector for 15 years to evaluate my teaching performance in class.”

When teachers were asked how evaluations should proceed, 48% answered that the process should include a multifaceted evaluation with the school principal’s participation; peer evaluation through visiting colleagues’ classes; and input from the inspector and students (i.e., via student evaluations). In addition, 48% of teachers responded that performance should be evaluated throughout the school year rather than in a single visit. Many teachers also wished that the inspector would serve the role of a mentor rather than an evaluator.

In terms of current teacher promotion practices, the majority of teachers (84%) were dissatisfied, claiming that promotion was inequitable based on a teacher’s years of experience; the authorities did not recognize teacher training at the graduate level (master and Ph.D.) or in other specializations. One teacher remarked,

The system is very bad; it is not adequate. There are teachers who do not update and are promoted only by the years of work they have as teachers. Teachers should be promoted by competition, [to] encourage them to continue [developing], [and] specializations [should] be valued and have an impact on wages.

About a quarter (28%) of responses mentioned unfairness in the teacher promotion method, and 16% pointed out the lack of recognition for extracurricular and graduate studies. When teachers were asked how the promotion system should operate, most (52%) answered that there should be a promotion test based on opposition and merit. About a quarter (28%) of respondents hoped for an integrated evaluation.
Teachers’ Needs

Survey results. In terms of RQ4 (“What resources and professional development opportunities do chemistry teachers in Uruguay report needing for instruction?”), 81% of teachers surveyed reportedly had an adequate laboratory room in the educational center. They also had glassware (98%), chemicals (76%), and analysis and measurement equipment (72%) they considered adequate for their teaching practices. However, about 40% of teachers responded that Internet access and the number of computers available were inadequate. Seven percent of teachers stated they did not have access to the Internet at school. Half (50%) of teachers in rural areas responded that their computers were in poor condition, and 25% had no computers in the school at all; likewise, 50% of rural teachers responded that laboratory conditions were inadequate.

Further analysis of the data from the survey, when teachers from rural areas were consulted about their needs in terms of resources, Internet access (75%) and analysis and measurement equipment (75%) were identified as urgently needed. Material resources such as books for classroom use (75%) were identified as somewhat needed. Teachers from urban areas also highlighted Internet access as urgently needed (71%), whereas fewer urban teachers identified analysis and measurement equipment and classroom books as necessary (58% and 64%, respectively). Interestingly, while the percentage of teachers who identified computers as somewhat necessary was 50%, the proportion was 69% for teachers in urban areas. Teachers in rural areas also did not identify laboratory rooms, glassware, or chemicals as highly necessary, potentially because these teachers did not consider these resources essential because they did not use them in their instructional practices. As mentioned in Chapter 3, rural schools incorporate early secondary education (e.g., the 7th, 8th, and 9th levels) into primary school, and laboratory
work is not required within the school program at these levels. For this reason, although the schools may not have such resources, teachers did not perceive them as necessary.

To further explore teachers’ needs related to professional development to improve their instruction, survey respondents were asked to select the topic on which they felt they needed more training. Response options ranged from 1 (not at all) to 5 (urgently needed). Findings showed that all professional development options were categorized as “somewhat needed” and “urgently needed” (60% of teachers or more), with effective teaching practices being the area in which most teachers reported needing training (84%).

Of the teachers surveyed from rural areas, 100% responded that professional development in content subject matter, laboratory skills, and effective teaching practices was “somewhat” or “urgently needed”; 78% of teachers in urban areas reported the same on the first two areas, with 83% stating effective teaching practices as professional development were either “somewhat” or “urgently needed.” Teachers from different school locations also identified similar professional development options as necessary, potentially because teacher training across Uruguay is centralized in the Secondary Education Council, a government agency that develops the curricula applied in different teacher training institutes and centers throughout the country.

Interview results. To develop a deeper understanding of teachers’ professional development opportunities and their willingness to complete professional development in the future, interview participants were asked if they had completed any professional development within the last year. They were also asked about which topics would be most helpful if they had the opportunity to take more professional development in the future. Results indicated that 72%
of respondents had participated in professional development during 2017, and 100% answered they would complete professional development in the future. One teacher said,

I would be interested in training in acquiring skills to perform experiments in the laboratory. But it is necessary that the administration of the school gives us the suitable conditions such as flexible schedules and that they allow us to use school hours to participate in professional development activities without [fear] of being sanctioned.

Table 4. 10 lists professional development activities that participants stated would be helpful in the future. Needed professional development was grouped into four categories: general and chemistry pedagogy, content knowledge, use of technology, and research methods in education. These results indicate that teachers interviewed had needs in terms of professional development and would be entirely willing to improve their training if they had the opportunity and appropriate conditions to do so. In Table 4. 11 courses needed by topic are summarized.

Table 4. 10 *Interview results: Professional development needed*

<table>
<thead>
<tr>
<th>Teachers’ desired professional development</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>General and chemistry pedagogy</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td>Content knowledge</td>
<td>15</td>
<td>60</td>
</tr>
<tr>
<td>Use of technology</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Research in education</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

*Note: Teachers’ answers included multiple materials and technology resources (N = 25).*
Table 4.11 *Interview results: Professional development needed*

<table>
<thead>
<tr>
<th>List of topics</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning disabilities</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>ICT tools for chemistry instruction</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Pedagogy and didactics in chemistry</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Laboratory skills</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Research methods in education</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Neuroscience and Cognitive Theories</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Assessment in chemistry instruction</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Philosophy of Chemistry</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Classroom management</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Problem based learning</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Sign Language</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Food Chemistry</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Quantum Chemistry,</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>
Teachers were also asked about materials and technology needed for instruction, which were coded across 8 categories: classroom supplies (e.g., furniture, whiteboard, markers, an air conditioner); computers; instructional technology (e.g., projectors and displays, an Internet connection); laboratory technology equipment (e.g., pH meters, balances, sensors); instructional supplies (e.g., books, 3D models of molecules); and chemicals, glassware, and safety equipment (Table 4. 11). Results showed that 44% of teachers needed instructional technology and laboratory technology equipment. Of teachers who reported needing classroom supplies (16%), one explained, “Furniture is needed, because [it is] over 40 years old and the students are not comfortable sitting there.” Other teachers responded that laboratory technology equipment was needed: “The [balance] scales that we have are very old, the institution does not have its own financial resources and we must ask for funding through the Secondary Education Council.” Some teachers pointed out that the lack of material resources was the school’s responsibility.

Table 4. 11 (continued)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Needed</th>
<th>Not Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics and physics for chemical education</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Atomic structure and Physicochemistry</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Environmental studies and renewable energies</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Organic Chemistry</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Innovation in chemistry laboratory</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Physicochemical sensors</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: Teachers’ answers included multiple materials and technology resources (N = 25).
One respondent noted, “What is needed is that the people in the school administration take seriously the management of resources to better use the materials in the school. The teachers need the resources [to be] well maintained and [in] working condition.” Another teacher shared,

Many things are needed, mainly for laboratories. Most of the things we have are donated, or we are using the materials [and] resources that were purchased at the time the center was created. Even many times when basic things are needed, we collect funds from teachers and students to buy them.

Other participants responded there were no opportunities for innovation in their instructional practices. One teacher said, “Many times you have to deal with what you have. If you want to innovate, you have to get the resources by yourself because the institution does not give them, there is no budget.” Some teachers indicated that even though resources were limited, resource management was poor:

Reagents and laboratory materials are needed in general. There is only one projector and there are very few books. There are very few computers, and most are broken. Also, there is a single TV installed in the library. … IT managers have the projector locked and they are not always at the center. Most of the time the staff is not there when they are needed

Another teacher mentioned, “There is only one computer room in the center, and it is not always available.”

Table 4. Interview results: Materials and technology resources

<table>
<thead>
<tr>
<th>Types of materials and technology</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional technology (e.g., projectors and displays, Internet connection)</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td>Laboratory technology equipment (e.g., pH meters, balances, sensors)</td>
<td>11</td>
<td>44</td>
</tr>
</tbody>
</table>
Table 4.12 (continued)

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>7</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glassware</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Computers</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Instructional supplies (e.g., books, 3D models of molecules)</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>Classroom supplies (e.g., furniture, whiteboard, markers, air conditioner)</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Safety equipment</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

*Note:* Teachers’ answers included multiple materials and technology resources ($N = 25$).

In all cases, teachers’ responses were negative regarding whether the institution had sufficient funds to buy instructional materials. Some respondents stated they needed more than material resources; one teacher said, “Not only laboratory materials are needed, but also a laboratory technician who assists us in the preparation of the material to carry out the experiments.” From the teachers’ answers, schools are clearly suffering from persistent problems in terms of limited resources as well as institutional constraints related to funding, administration, distribution, and maintenance of resources.

At the end of the interviews, teachers were asked if they needed additional support. Their answers revealed four categories in which additional support was warranted: teamwork, support from school management, mentoring, and teacher training. Nearly a quarter (24%) of teachers interviewed stated they would like to receive support from school management and from their colleagues through teamwork. One teacher said, “What I need most is to work with teachers in the same area to coordinate classes and work with teachers in different areas for an
interdisciplinary approach.” Another participant remarked, “We need recognition from the
school director and the regional supervisor that they value that you try to do things right.” One
out of five teachers felt they would need mentoring from experienced teachers; a teacher noted,

What I need is the contribution of colleagues who are in the same field and can guide me
in more complicated topics such as thermodynamics or chemical equilibrium. The
students have a hard time with these subjects because they have little basic knowledge of
them, so it is hard for us to teach them.

Slightly more than a quarter (28%) of teachers responded they needed additional opportunities
for teacher training as part of their professional development. They also indicated other social
problems for which they required support from specialists and interdisciplinary teams. For
example, one teacher said,

Psychologists and social workers are needed at the school on a permanent basis. The
school management always waits for something to happen to act. They should evaluate
the students and detect difficulties. … Support teachers are needed for struggling
students, and social workers are needed to make visits to the students’ homes so that they
can follow up on the student and their families. For example, there are cases of domestic
violence and changes in the household (they move to another place, they live with other
people who are not of their family). … Most of the time there are no family members, no
one to communicate with when there is a problematic student.

Another teacher stated,

There is a need for interdisciplinary teams of psychologists, social workers, etc. so we
can consult [with] them about the students and also support the teachers emotionally. In
this profession you are totally alone. We need someone to be there to support us.

Finally, when teachers were asked to share any other concerns or comments, their
answers pertained to current educational policies, students’ family and social backgrounds,
feelings of loneliness when facing student-related problems, the precariousness of the job, and
the lack of recognition for their effort and academic training. One teacher referred to the current
educational policies as follows:

There was a change for the worse, a setback with respect to the previous work model, and
now we have fewer guidelines. The work turned to a propaedeutic approach, rather than
preparing the student for life. Teaching is no longer centered on the student, and the needs of the student are not met. There is also an ambiguity in the political discourse because one thing is said and another is done.

Another teacher shared about the precarious nature of the job, stating,

An adequate environment is needed for better teaching, fewer students per class, and an education community [composed] of teachers. It is even necessary that teachers have the possibility to focus all their class hours in a single center and that they should not have to travel several times a day to a different school to teach. The multi-employment causes that you cannot have effective time management, and that [affects] the quality of the teacher’s work.

Yet another teacher said,

The system has to change, it is obsolete, the programs are inadequate and not interesting to the students. It is necessary that the teacher has a certain number of hours assigned to a single school, and that a number of hours are also assigned for coordination with other teachers and for the teacher’s training. In most cases, we are penalized if we take courses as part of our professional development during class hours.

Teachers also referred to the influences of the family and the socioeconomic context on students’ academic performance. One respondent lamented,

You are one teacher and you have 20 students with difficulties and only five who follow the class. As a consequence, there is an important student dropout. In addition, the teaching staff changes every year, and there is no stable teaching body. There is no emotional support or demands from the students’ households. Most of the students only come to socialize but not because there is an interest in learning.

In reference to the lack of recognition and academic training, one teacher responded,

In Uruguay, chemistry teachers should all have academic teacher training [many don’t]. In some cases, it may work out because teachers have a natural ability to teach, but it can go very wrong if they do not have training. Many teachers have no academic training and no interest in professional development, but we are all evaluated equally because what matters are years in-service as a teacher.

Another teacher said,

There is a significant deficit of trained teachers. The majority are non-graduate teachers, and that generates a serious situation since they teach chemistry and physics. This makes me angry. The system is weighted against ongoing training of teachers. For example, I was doing a neuroscience course and the head of the school administration [director] did not justify my absences and deducted my salary hours. This discourages me, the teaching
work is outrageous. The difference between those who have just graduated and those who do not have a degree is only 7.5% salary compensation.

About half of the teachers who responded to this open-ended question referred to points of contention with the school administration (59%) and teachers’ preparation (53%).

Overall, most chemistry teachers surveyed felt their preparation gave them skills to promote student learning, to use technology during instruction, and to promote critical thinking in students. Conversely, a high percentage of teachers believed that student learning was not attributable to teachers’ personal effectiveness in teaching chemistry. When differentiating on the basis of experience, findings revealed significant differences between novice and experienced teachers in feeling prepared to promote student learning and to use technology during instruction; however, no significant differences emerged in their beliefs that teachers can influence student learning or how often teachers use technology during instruction. In the next chapter, these findings will be discussed in greater detail to clarify teachers’ perceptions of their skills and their confidence in what they can accomplish as chemistry teachers in the future.
Chapter 5: Discussion and Conclusion

In this chapter, results are summarized and conclusions are drawn from the data. A discussion of relevant findings, implications for action, and recommendations for future research are provided.

Teacher Preparation

According to the findings, teachers generally felt prepared to teach chemistry in ways that promote learning and critical thinking among students; however, a high percentage did not feel well prepared to identify or address students’ learning needs and difficulties. Teachers also felt prepared to use different tools and approaches in their science instruction. Most tools were related to cultivating students’ science process skills, such as by encouraging students to think critically and solve problems; develop questioning and discussion skills; and identify, question, and understand ideas from diverse perspectives.

Teachers were also comfortable setting challenging expectations related to students’ learning. Teachers felt they possessed requisite skills and were confident in their ability to carry out such tasks in the future. Teachers were highly confident that they had the preparation not only to teach chemistry effectively, but also, they felt capable of piquing students’ interest in chemistry and were continually working to improve their own teaching practices. However, when considering how often these pedagogical strategies were reportedly used, the results are far from what was expected. During instruction, teachers stated that students either never or occasionally engaged in tasks such as developing problem-solving skills, making testable predictions, devising rational explanations for the results of an experiment or investigation, choosing the most appropriate methods to report results, or implementing activities in a real-world context. Moreover, a considerable percentage of teachers noted their students never used
tools to gather data (e.g., calculators, computers, computer programs, scales, or measurement units). Conversely, the Next Generation Science Standards (National Research Council, 2013) that outline goals and reflect what students should know and be able to do to be scientifically literate in 21st-century society, highlight that students should ask questions and define problems, develop and use models, analyze and interpret data, plan and carry out investigations, use mathematics and computational thinking, construct explanations and design solutions, engage in argument from evidence, and obtain, evaluate, and communicate information (National Research Council, 2012, p. XVI). In light of the results, chemistry teachers surveyed do not seem to be focusing their teaching practices to achieve these goals, and on the contrary, they are far from reaching them.

When exploring teachers’ preparation to use technology and how often their students used technology during class, results were similar: although teachers felt prepared to use technology to support their instruction, their students apparently never used technology during the class to support higher-order thinking (e.g., analysis, synthesis, and evaluation of ideas and information); work on technology-supported projects that included technology applications in the real world; or create new ideas and representations of information to help solve problems. Also, students never used the same kinds of tools that professional researchers tend to use, such as simulations, databases, and laboratory equipment. This is an important issue because according to the standards (National Research Council, 2013), students should be immersed in inquiry-based activities to comprehend the nature of scientific knowledge by experiencing the major practices scientists develop when they investigate and build models and theories. Teachers did not report providing students with an organizational structure to help them understand, make sense of, and even connect disciplinary core ideas across disciplines. Students should also be
prepared with core knowledge in science that enables them to evaluate and select trustworthy resources of scientific information while preparing them to acquire additional information on their own in the future (National Research Council, 2012).

By contrast, teachers reported working in small groups and making observations and measurements as the most common instructional practices, along with using technology to access online resources and information and to communicate and collaborate with others outside the classroom. From the survey and interview results, teachers stated they urgently needed Internet access at school and computers in better condition. They also identified needing additional instructional technology and laboratory equipment. The implications of this situation clearly affect the quality of teaching. If teachers have limited resources and the institution has no funding to afford new materials or technology resources, there will be little opportunity to innovate through new educational practices or even support basic educational practices. On more than one occasion during interviews, teachers complained that they had to teach only with resources available in their institution; if they wanted to innovate, they had to obtain more resources themselves, either by using their own funds’ or the students’ funds.

Another reason why teachers don’t use further instructional practices beyond those mentioned above may be that teachers feel unprepared to work with certain student populations. Although teachers reported feeling prepared in terms of content knowledge and instructional strategies, they were not prepared in pedagogy to teach chemistry (i.e., pedagogical content knowledge), and to use pedagogical tools that would enable them to teach a heterogeneous population of students, including those with learning and behavioral problems. For example, one teacher said, “[Students] have difficulties that have not been diagnosed, [such] as learning or behavioral [difficulties]. As teachers, we realize that they have some problems, but we do not
know how to give a diagnosis.” In interviews, some teachers said that during their training, the institute prepared them to teach an ideal class with students motivated to learn; however, the reality they face every day is quite different. Many teachers cited a need for multidisciplinary teams of psychologists and social workers to help students with difficulties and support teachers when encountering situations such as domestic violence or abandonment. Teachers also reported struggling with a population of students who reached secondary school with basic problems related to language and reading comprehension, insufficient prior knowledge, or learning disabilities. Teachers also argued that the number of students in class did not allow them to tailor instruction to students’ needs, making the good ones undervalued while the bad student disturbs the class, leaving teachers little time to encourage top-performing students. Nonetheless, teachers could be granted additional support through professional development opportunities that would enable them to deploy an array of strategies to promote higher-order thinking according to students’ learning needs and with few resources. This topic is addressed further in the section below.

**Teachers’ Self-efficacy and Behavioral Change**

As indicated in the literature review, teachers’ self-efficacy is related to teachers’ convictions that they can influence student learning whenever students are challenging or unmotivated. Bergman, McLaughlin, Bass, Pauly, and Zellman (1977) defined a teacher’s sense of efficacy as her belief that she is capable of influencing student performance. Results of the current study reveal an apparent contradiction between what is reported in the literature and what teachers actually say. Although teachers felt highly confident in their teaching skills, in that they possessed the skills needed to teach chemistry effectively and knew how to help students understand chemistry concepts, they did not believe their actions could influence student
learning. Moreover, they did not believe that the level of student learning (whether lower or
greater than expected) could be influenced by the effectiveness or ineffectiveness of their
teaching practices; that extra effort from the teacher could lead to better student performance in
chemistry than usual; or that minimal student learning in chemistry could generally be attributed
to teachers. In terms of preparation, roughly 30% of teachers admitted they did not feel prepared
to help students achieve high academic standards or develop a curriculum that builds on
students’ experiences, interests, and abilities. Half of the teachers in this study felt underprepared
to identify and address students’ learning needs and difficulties. Therefore, these findings suggest
a lack of preparation and low teacher expectancies regarding student outcomes. If teachers do not
believe they are responsible for students’ learning, then external factors may play important
roles. During interviews, teachers identified abstract thinking, previous concepts, students’
beliefs, and students’ interest as factors affecting what students learn in chemistry. Moreover,
teachers believed the main sources of student motivation were the teacher, the family, and
students’ intrinsic motivation.

Teachers’ perceptions of their students’ performance could be associated with personal
locus of control, a term coined by Rotter (1966) to identify a non-cognitive behavior associated
with the personality dimension of internal and external locus of control. This concept is based on
the nature and effect of reinforcement that strengthens an expectancy. Individuals’ expectancy
refers to the nature of the causal relationship between their own behavior and consequences that
might condition behavioral choices in different situations. When an individual believes that
outcomes are determined by his or her own behavior, then he or she is identified as having an
internal locus of control; for an individual with an external locus of control, he or she believes
that outcomes are determined by chance, luck, or others’ actions (Heywood, 2017). Internal or
external control is built from an individual’s perception of reinforcement as “contingent upon his own behavior” (Rotter, 1966, p. 5); that is, positive or negative reinforcement will strengthen or weaken the selection of that behavior in similar situations in the future. When this pattern is transferred to teaching practices, teachers with an expectancy of internal control will likely perceive classroom events, such as students’ performance, as a consequence of their own actions and under personal control, whereas teachers with an external locus of control are apt to perceive students’ outcomes as influenced by factors beyond the teacher’s control.

The teachers who participated in this study seemed to predominantly possess an external locus of control. Two factors may inform this pattern. One is the possibility that teachers had persisted in trying to improve students’ performance and ultimately gave up after not receiving positive results; this trend would reinforce that, although teachers felt trained and had used different teaching practices, they gradually concluded that their own efforts and dedication were insufficient to improve students’ performance. Teachers may then identify other factors intrinsic to the student and external factors (e.g., family) as shaping students’ learning outcomes and motivation.

In addition, other factors such as fear (e.g., teacher failure) could be explored. Savage, Stearns and Friedman (1979) stated that people who presented an external locus of control (i.e., believed their actions did not affect results, which were instead thought to be controlled by chance or other factors) showed significantly more fear of success than those with internal locus of control. In the context of the present study, if teachers assume, they are responsible for students’ achievements and their students then do not attain the expected performance, all responsibility would fall on the teacher. Taking a less committed and more circumstantial position frees teachers from engaging in introspection around their teaching practices and
weaknesses. Limited space for communication with other teachers also apparently causes teachers to feel lonely and as though they cannot share their insecurities about their teaching practices. Perhaps teachers’ professional development should focus less on content knowledge and be offered more space within the institution so colleagues can share their experiences, reflect on their teaching practices, and receive support from more experienced teachers to enhance their own performance and that of their students.

Other factors that may be associated with a lack of positive reinforcement from educational authorities are teachers’ training and performance. In interviews, teachers expressed widespread discontent with performance evaluations and the teacher promotion system. Teachers also cited a sense of alienation and powerlessness due to a lack of support from the institution. Teachers did not consider improvements in their teaching practices, efforts to be trained at the graduate level, and professional development activities to be worthwhile for evaluation or promotion. Results revealed that teachers’ evaluations depended, in the best cases, on an intermittent inspector visit once every 10 or 15 years where only administrative issues or school program progress were assessed. With respect to the teacher promotion system, only the number of years as an in-service teacher were included; in most cases, extracurricular courses and graduate-level training were not considered merits for promotion. For example, one teacher said, “The system is very bad; it is not adequate. There are teachers who do not update and are promoted only by the years of work they have as teachers.” Some teachers even reported having been penalized for taking courses during class hours. Teachers’ concerns were focused on additional factors that have an impact on their performance such as the quality of teaching work in terms of time management due to the multiple stream employment, and the inadequacy of programs that are no longer interesting to students. These findings reveal a series of factors that
are affecting the ability of teachers to teach in an adequate work environment and go beyond their preparation and confidence; such factors seem to be related to institutional constrains and educational policies.

In light of these results, further research is needed to understand why teachers do not use technology regularly in their instruction if they feel prepared and confident using it. Studies should also explore why students only use technology in a basic manner. The same can be said for teachers’ ability and confidence to develop students’ higher-order skills and critical thinking. Although attempts were made to explain this finding, the commentary in this study is mere speculation; a more comprehensive investigation of causes should be conducted to elicit concrete findings. Such research should incorporate various tools, such as teaching observations during class instruction, in-depth interviews where teachers are asked which factors inspire the prioritization of certain behaviors in their teaching, and discussion groups where teachers have an opportunity to exchange experiences and identify strengths and weaknesses in their teaching practices.

**Teachers’ Perceived Instructional Needs**

Based on the results of this study, teachers’ needs can be divided into two broad categories: those for material and technological resources and those related to professional development opportunities. In the first category, among teachers surveyed, access to the Internet and computers in good condition were urgently needed, followed by analysis and measurement equipment; books to use in the class ranked third in terms of priority. Interviewed teachers identified their needs in greater detail, citing eight categories: classroom supplies (e.g., furniture, whiteboard, markers, and an air conditioner); computers; instructional technology (e.g., projectors and displays; an Internet connection); laboratory technology equipment (e.g., pH
meters, balances, and sensors); instructional supplies (e.g., books and 3D models of molecules); and chemicals, glassware, and safety equipment. Instructional technology and laboratory technology equipment were the most needed resources followed by chemicals and glassware. Although teachers stated they had a laboratory room, chemicals, and glassware, they also highlighted these components as necessary. The same sentiment applied to access to the Internet and computers, even though all primary and secondary students in public schools now have their own laptop and Internet access at school and public places owing to the Ceibal Plan. Teachers’ reported needs related to these resources may have been associated with maintenance conditions. In interviews, some teachers highlighted a lack of maintenance of materials and technological resources in schools. Teachers also tended to identify as necessary those instruments, they used most often while teaching; therefore, instructional technology resources may not have been identified as a priority because students more often use technology to communicate, collaborate, and access online resources. However, teachers stated they felt prepared and confident to use technologies for a wide spectrum of activities. A high percentage of teachers had taken relevant courses in the last year and highlighted technology as a topic that would be of great help in the future. Overall, although teachers felt confident and prepared to use technologies, this knowledge was not transmitted to students who apparently only made basic use of these tools. Perhaps teachers’ need more specific preparation through professional development opportunities to incorporate technology for effective teaching practices.

A striking point is that only two teachers identified laboratory safety equipment as necessary, which should be a priority for any teacher who uses experimental demonstrations as a tool for teaching science. This finding suggests that schools have good safety equipment and adequate infrastructure for laboratory practices. However, given teachers’ responses in
interviews and the author’s knowledge (after having visited several schools to collect data for this study), schools, in fact, do not have the minimum safety conditions in terms of infrastructure and equipment. Teachers’ responses can thus be interpreted in two ways: either teacher do not use a laboratory as part of teaching, or they do not know the required safety measures. The second option may not have a place in this study, as nearly 100% of teachers said they felt prepared to teach laboratory safety. In that case, one can only assume that chemistry teachers do not regularly integrate experimental work into their teaching practice or even they didn’t have training in safety equipment during their preparation. In chemistry, an area of science in which experimental work is essential, it is worrisome that students may not experience for themselves the work scientists do. This potential omission dilutes students’ opportunity to understand basic chemical phenomena that can only be fully grasped through experimental work. Interviews elicited explanations that may explain teachers’ behavior in this regard: a large student population per class, the lack of a laboratory technician to support teaching tasks, the distance between the classroom and laboratory, and the limited class time teachers are afforded because ‘class time’ is 45 minutes. In the best case, teachers meet classes for 90 minutes once a week.

The other identified category was the need for teachers’ professional development. Most teachers interviewed stated they had taken a course as part of professional development, and 100% noted they would be willing to participate in similar classes or activities in the future. Teachers interviewed also identified a list of topics they considered especially useful for their teaching practices; most topics were related to science content knowledge followed by general and chemistry pedagogy. Many teachers wanted more professional development around working with students with learning disabilities; however, the proportion of students with such conditions is fairly low in a regular class. Teachers seemed to aim to meet the needs of students with greater
difficulties while somewhat neglecting those who performed better. Teachers appeared to assume that if a student understands the given tasks, then he or she does not need additional attention. A major problem that could result from this attitude is good students not being encouraged to improve their performance and achieve high academic standards.

**School Location and Teaching Experience**

The effect of teaching experience on teachers’ preparation, the use of technology and instructional practices, and teachers’ self-efficacy indicated that experience only affected teachers’ preparation in terms of promoting student learning and using technology. Experienced teachers felt better prepared than novice teachers to understand how different students in their classroom were learning, to help all students achieve high academic standards, and to create a discipline-based and interdisciplinary curriculum. Regarding technology use, experienced teachers reported feeling better prepared to use technology to support students’ research and analysis; however, no differences were found in the lack of teachers’ preparation and its influence on understanding, identifying, and addressing various factors that influence student learning. No differences emerged in the preparation of experienced and novice teachers in terms of promoting students’ critical thinking and social skills or how confident either group of teachers was in teaching chemistry. Additionally, no differences emerged in teachers’ perceptions of how their actions influenced student learning or in the instructional practices and technologies they used while teaching. Essentially, novice teachers seemed to feel they were equally prepared, possessed the same skills, and were just as confident in their teaching practices as experienced teachers.

Teachers from urban and rural areas identified the same resources as being required (e.g., Internet access). They also identified similar professional development options as necessary,
potentially because all teachers across Uruguay have been trained using the same curricula developed by the Secondary Education Council.

**Recommendations**

The results of this study have inspired several recommendations, including some that could have a direct impact on teachers and others that would depend more heavily on educational authorities.

**Opportunities for professional development.** For students to understand how scientific knowledge is developed, teachers must be able to use approaches that encourage students through tasks to develop higher-order thinking. For example, for students to understand inquiry as a tool to learn science, teachers should be well-versed in inquiry-based methods; teachers should thus have learned science through inquiry or have conducted scientific inquiry independently. Teachers should also possess the understanding and skills necessary to apply inquiry seriously and appropriately in their classes. Through professional development, teachers should familiarize themselves with new methodologies and tools for their teaching practices. Such development can also serve to redirect teaching and learning toward these methodologies.

Some recommendations regarding course design for teacher training (National Research Council, 2012) highlight teachers’ need to have a strong understanding of the scientific ideas and practices they will teach along with knowledge of how scientists collaborate to develop new theories, models, and explanations of phenomena. Teachers must also understand the knowledge and ideas students bring to their classes and recognize students’ existing scientific background to be able to teach new concepts. Importantly, teachers need to learn science-specific pedagogical content knowledge to choose appropriate pedagogical approaches and help students develop a greater scientific understanding that builds on their existing knowledge base. Professional
development courses or workshops focusing on these topics should, therefore, be created, after which a group of experienced teachers could complete the implementation process in class.

Another way to induce changes in teachers’ behavior when teaching science could involve peer-to-peer work drawn from Japanese Lesson Study (Doig & Groves, 2011), where teachers study their own practices in communities of inquiry. In Uruguay, this type of methodology could be applied in various educational centers with relative success—even more so because work among peers, coordination of activities, and experienced teachers’ mentoring of novice teachers have been highlighted in this study as areas warranting attention.

**Teachers’ evaluations of the performance and promotion system.** Teachers’ opinions regarding performance evaluations and the promotion system were nearly uniform; instructors completely disagreed with both processes and demanded change. Teachers noted that evaluations should be multifaceted and include the following: the school principal’s participation; peer evaluations by visiting colleagues’ classes; and input from the inspector and students (i.e., via student evaluations). Teachers also claimed that performance should be evaluated throughout the school year rather than in a single visit. In addition, the inspector should serve the role of a mentor rather than an evaluator. For this goal to be achieved, more inspectors should be involved in evaluations (currently there are only two for all of Uruguay), but the objective of evaluations should shift to a continuous format to improve teachers’ performance. The promotion system should also evolve, including by incorporating performance evaluations as a judgment criterion. The system should recognize ongoing teacher training, either through graduate studies or extracurricular courses. At a certain point, an opposition and merit test should be given to assess a teacher’s candidacy for promotion.
Conclusion

This study presents an exploratory investigation of a sample of chemistry teachers in Uruguay. Although results cannot be generalized to the entire teaching population, some worrying indicators of teachers’ behavior in relation to their teaching practices have come to light, sounding a warning signal and informing suggestions of how to improve the situation. Teachers seem to choose certain tools and strategies over others to teach concepts and phenomena in chemistry; however, it is concerning that instructor do not challenge students to the best of students’ cognitive capabilities and instead focus on developing lower-order thinking, where creativity and critical thinking have no place. Without intending to place full blame on teachers, it is also clear that what teachers ultimately teach is influenced by decisions made at higher levels of the education system; that is, if teachers are required to ensure that students achieve a certain level of performance, then teachers will strive to help their students accomplish it. Conversely, if teachers are only required to comply in time and form with the curriculum irrespective of how much students learn, then those teachers will not focus their efforts on students’ learning. According to interviewees, the system for evaluating teachers’ performance of teachers does not encourage constant improvement in their teaching practices; inspectors’ roles appear to focus more on strict examinations than guidance or mentoring. Curricula at different levels of secondary education also do not seem to be student-focused.

Another point worth highlighting is the contradiction between teachers’ reportedly high self-efficacy for teaching chemistry and the comparatively limited sense of responsibility they possess for students’ learning. This trend was evidenced by explicit answers to the survey and interviews as well as in the professional development opportunities in which teachers were interested. Their responses stated little related to how students learn, how to improve students’
performance, or how to improve their teaching practices to prepare individuals who are scientifically literate or capable of developing science in the future. None of the teachers expressed the need to prepare students to pursue a STEM career in college. Given that chemistry is central to the development of scientific knowledge along with physics and biology, teachers should realize that students’ future performance in science and their potential future STEM careers depend on teachers. If instructors cannot motivate and inspire their students on scientific issues, little hope remains for Uruguay to foster a larger population of STEM professionals to leverage their knowledge to promote the country’s development.
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Appendix A: Survey Invitation Email

Hello,

You are invited to participate in a study of chemistry instruction in Uruguay. I am a Chemistry Educator from Uruguay and am conducting a study of Chemistry teachers' instruction and needs.

Please consider participating in the study by completing a brief online survey.

The goal of this study is to determine how chemistry teachers are prepared, their instructional practices, and even more importantly what are your needs for future professional development as well as your needs for materials and equipment. This information can be used by education leaders in Uruguay to provide you with more support for your teaching. If you agree to participate you will be in a drawing for a $35 gift card.

To answer the survey, please click on the following link. The survey will take about 20-30 minutes to complete. Your responses will be confidential and your name will not be used in reporting any of the data.

Click here to begin:  http://............ (URL will be inserted)

We know this is a busy time of the year, but your feedback is highly valuable and may be used to improve chemistry teaching!

Thank you in advance for your time and participation.

Sincerely,

Ph.D. Candidate Mariana Pereyra

College of Education

NC State University
Appendix B: Survey Consent Form

North Carolina State University
INFORMED CONSENT FORM for RESEARCH

Title of Study: Chemistry Teachers Preparation, Self-Efficacy, and Professional Development Needs in Uruguay

Principal Investigator: Mariana Pereyra (mpereyr@ncsu.edu),
Faculty Sponsor: Dr. Gail Jones (Gail_Jones@ncsu.edu)

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of this study is to gain a better understanding of Chemistry teachers’ professional development and resource needs. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researchers named above.

What is the purpose of this study?
This study will document how Chemistry teachers in Uruguay are prepared, their needs for professional development, and resources needed to teach chemistry. The goal is to determine how Chemistry teachers can be supported in their future work.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to complete an online survey. The survey will ask you to share your beliefs about teaching Chemistry, your instructional practices, as well as information about the behaviors and perceived beliefs of your students. You will be asked about your preparation for teaching chemistry and the materials and equipment you believe you need for your classroom. You will need approximately 30 minutes to complete the online survey. You will not be asked to put your name on the survey.

Risks
No foreseeable risks or discomforts are expected from your participation in this study. Survey data will be summarized and no data will be identifiable by your name. Data will only be reported by group and no names will be used.

Benefits
There will not be a direct benefit for the teachers who participate in the survey, but the information collected will be very useful for policy makers, leaders, and educators to use as they prepare future teachers and design new programs to support chemistry instruction. Hopefully the survey can help administrators’ better support the work you do.

Confidentiality
The information in the study records will be kept confidential to the full extent allowed by law. Data will be stored securely in password-protected and university protected website that has been deemed as highly secure. No reference will be made in oral or written reports which could link you to the study. You will NOT be asked to write your name on any study materials so that no one can match your identity to the answers that you provide.

Compensation
For participating in this study you will be in a drawing for a $35 gift card.
What if you have questions about this study?
If you have questions at any time about the study or the procedures, you may contact the researcher, Mariana Pereyra (mpereyr@ncsu.edu) or Dr. Gail Jones (Gail_Jones@ncsu.edu), Friday Institute for Educational Innovation at North Carolina State University, Raleigh, 27695, (01-919-513-8525).

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator at dapaxton@ncsu.edu or by phone at 1-919-515-4514.

Consent To Participate

“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may withdraw at any time.”

☐ Yes, I agree to participate with the understanding that I may withdraw at any time. By continuing with this online survey I acknowledge I agree to participate.

☐ No, I decline to participate.

Subject's (teacher) signature_________________________________ Date _____________

Investigator's signature____________________________________ Date ___________
Appendix C: Interview Consent Form

North Carolina State University
INFORMED CONSENT FORM for RESEARCH

Title of Study: Chemistry Teachers Preparation, Self-Efficacy, and Professional Development Needs in Uruguay

Principal Investigator: Mariana Pereyra (mpereyr@ncsu.edu),
Faculty Sponsor: Dr. Gail Jones (Gail_Jones@ncsu.edu)

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in this study is voluntary and is not a job requirement. You have the right to be a part of this study, to choose not to participate or to stop participating at any time without penalty. The purpose of this study is to gain a better understanding of Chemistry teachers’ professional development and resource needs. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you are being asked to participate. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researchers named above.

What is the purpose of this study?
This study will document how Chemistry teachers in Uruguay are prepared, their needs for professional development, and resources needed to teach chemistry. The goal is to determine how Chemistry teachers can be supported in their future work.

What will happen if you take part in the study?
If you agree to participate in this study, you will be asked to participate in a brief interview. The interview will ask you to share your experiences teaching Chemistry, your instructional practices, as well as information about your needs for professional development. You will be asked about your preparation for teaching chemistry and the materials and equipment you believe you need for your classroom. You will need approximately 30 minutes to complete the interview.

Risks
No foreseeable risks or discomforts are expected from your participation in this study. Interview data will be summarized and no data will be identifiable by your name. Data will not be reported in a way that anyone could identify you.

Benefits
There will not be a direct benefit for the teachers who participate in the interview, but the information collected will be very useful for policy makers, leaders, and educators to use as they prepare future teachers and design new programs to support chemistry instruction. Hopefully the survey can help administrators’ better support the work you do.

Confidentiality
The information in the study records will be kept confidential to the full extent allowed by law. Data will be stored securely in password-protected and university protected website that has been deemed as highly secure. No reference will be made in oral or written reports which could link you to the study. Your name will not be used in reporting the data.

Compensation
For participating in this study you will not receive any compensation.
What if you have questions about this study?
If you have questions at any time about the study or the procedures, you may contact the researcher, Mariana Pereyra (mpereyr@ncsu.edu) or Dr. Gail Jones (Gail_Jones@ncsu.edu), Friday Institute for Educational Innovation at North Carolina State University, Raleigh, 27695, (919-513-8525).

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Deb Paxton, Regulatory Compliance Administrator at dapaxton@ncsu.edu or by phone at 1-919-515-4514.

Consent To Participate

“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may withdraw at any time.”

☐ Yes, I agree to participate with the understanding that I may withdraw at any time.
☐ No, I decline to participate.

Participant's (teacher) signature_____________________________ Date _____________

Investigator's signature_____________________________ Date _____________
Appendix D: Interview Invitation Email

Text to recruit teachers for study

Dear Sr./Madam,

You are invited to participate in a study to provide insight into your chemistry teacher preparation, your needs of resources for instructional and laboratory practices, and professional development opportunities. We are also interested in your opinion about your teaching performance evaluation.

If you are interested in participating, please reply to this email to schedule a day and time to do the interview. Your responses will be completely confidential and your information will be stored securely in password-protected file.

The interview will take you about 30 minutes.

Your participation is completely voluntary and your participation is not a job requirement. Your responses will help to better understand what your needs are and where chemistry teachers' preparation needs to make improvements. Results from the interview also provide essential data to help in the design of future strategies to improve teaching chemistry practices.

We know this is a busy time of the year, but your feedback is highly valuable! Thank you in advance for your time and cooperation.

Sincerely,
PhD student Mariana Pereyra
College of Education
NC State University
Appendix E: Chemistry Teachers Survey

Demographics

Q1.1: How many years of teaching experience do you have in chemistry?

- One year (1) (1)
- Two to five years (2-5) (2)
- Six to ten years (6-10) (3)
- More than ten years (>10) (4)
- Retired teacher (5)

Q1.2: What type of school do you currently teach?

Public

- Secondary School (1);
- Technical School (2);
- Teacher Education (3)

Private

- Secondary School (1);
- Technical School (2);
- Teacher Education (3)

Q1.3: What grade(s) do you currently teach?

- Lower Secondary Education (1st, 2nd, 3rd) (1);
- Upper Secondary Education (4th, 5th, 6th) (2);
- Teacher Education (IFD, IPA, CERP) (3);
• Other (please specify) (4)

Q1.4: In which locations do you currently teach?


Q1.5: Which setting best describes the community in which your school is located?

• Urban/city (more than 5000 population) (1);
• Rural (less than 5000 population) (2)

Q1.6: What is your gender?

• Female (1)
• Male (2)


• African or Black (1)
• Asian (2)
• Caucasian or White (3)
• Indigenous (4)
• Other (please specify) (5)
Teacher Efficacy and Attitudes Toward Teaching Chemistry

Thank you for taking the time to participate in the study. The goal of this research is to learn more about your thoughts regarding chemistry education, through the study of teacher self-efficacy and attitudes toward Chemistry. This survey does not ask you to directly rate or critique the content of your teacher preparation program. Rather, you will be asked about your beliefs in Science, Technology, Engineering, and Mathematics (STEM) and instructional practices, as well as information about the behaviors and perceived beliefs of your students. Please take a few minutes to provide information about your current level of confidence in teaching Chemistry related content. The survey should take approximately 15 minutes to complete.

DIRECTIONS:
For each of the following statements, please indicate the degree to which you agree or disagree each statement. Even though some statements are very similar, please carefully answer each statement. There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help make your choice.

Chemistry Teaching Efficacy and Beliefs

Q2.1 Directions: Please indicate the degree to which you agree or disagree with the following statements referred to your teaching experience.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am continually improving my chemistry teaching practice.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. I know the steps necessary to teach chemistry effectively.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. I am confident that I can explain to chemistry why science experiments work.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. I am confident that I can teach chemistry effectively.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. I have the necessary skills to teach chemistry.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6. I understand science concepts well enough to be effective in teaching chemistry.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. I would invite a colleague to evaluate my chemistry teaching.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>8. I am confident that I can answer students’ chemistry questions.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>9. When a student has difficulty understanding a chemistry concept, I am confident that I know how to help the student understand it better.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>10. When teaching chemistry, I am confident enough to welcome student questions.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>11. I know what to do to increase student interest in chemistry.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

**Science Teaching Outcome Expectancy**

Q2.2 **Directions:** The following questions ask about your feelings about teaching *in general*. Please respond accordingly.
Student Technology Use

Q2.3 Directions: Please answer the following questions about how often students use technology in settings where you instruct students. If the statement is not applicable to your situation, please select “Not Applicable”.

During science instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.), how often do your students...

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Occasionally</th>
<th>About half the time</th>
<th>Usually</th>
<th>Every time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Use a variety of technologies, e.g. productivity, data visualization, research, and communication tools.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Use technology to communicate and collaborate with others, beyond the classroom.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Use technology to access online resources and information as a part of activities.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Use the same kinds of tools that professional researchers use, e.g. simulations, databases, laboratory equipment.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. Use technology to help solve problems.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6. Use technology to support higher-order thinking, e.g. analysis, synthesis, and evaluation of ideas and information.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. Use technology to create new ideas and representations of information.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>8. Use technology to help solve problems.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Science Instruction

Q2.4 Directions: Please answer the following questions about how often students engage in the following tasks during your instructional time.

During science instructional meetings (e.g. class periods, after school activities, days of summer camp, etc.), how often do your students...

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Occasionally</th>
<th>About half the time</th>
<th>Usually</th>
<th>Every time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop problem-solving skills through investigations (e.g. scientific, design or theoretical investigations).</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Work in small groups.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
3. Make predictions that can be tested.  ○ ○ ○ ○ ○ ○

4. Make observations or measurements  ○ ○ ○ ○ ○ ○

5. Use tools to gather data (e.g. calculators, computers, computer programs, scales, measurements units etc.).  ○ ○ ○ ○ ○ ○

6. Recognize patterns in data.  ○ ○ ○ ○ ○ ○

7. Create reasonable explanations of results of an experiment or investigation.  ○ ○ ○ ○ ○ ○

8. Choose the most appropriate methods to express results (e.g. drawings, models, charts, graphs, technical language, etc.).  ○ ○ ○ ○ ○ ○

9. Implement activities with a real-world context.  ○ ○ ○ ○ ○ ○


12. Reason quantitatively.  ○ ○ ○ ○ ○ ○

13. Critique the reasoning of others.  ○ ○ ○ ○ ○ ○

14. Learn about careers related to the instructional content.  ○ ○ ○ ○ ○ ○

**Teacher Leadership Attitudes**

Q2.5 **Directions:** Please respond to the following statements regarding your feelings about teacher leadership in general. "I think it is important that teachers..."

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Take responsibility for all students’ learning.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Communicate vision to students.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Use a variety of assessment data throughout the year to evaluate progress.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Use a variety of data to organize, plan, and set goals.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. Establish a safe and orderly environment.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6. Empower students.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Directions:

For each of the following statements, please indicate the degree to which your answers that best fit your personal or professional experience as a secondary school teacher.

Although some statements are very similar, please answer each statement. There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, pull from your personal experience help you make the choice.

Q3.1 How well prepared do you feel to do the following?

<table>
<thead>
<tr>
<th>Promote Student Learning</th>
<th>Not well prepared</th>
<th>Prepared</th>
<th>Well prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Teach subject matter concepts, knowledge, and skills in ways that enable students to learn.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Understand how different students in your classroom are learning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Set challenging and appropriate expectations of learning and performance for students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Help all students achieve high academic standards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Develop curriculum that builds on students’ experiences, interests, and abilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Evaluate curriculum materials for their usefulness and appropriateness for your students</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Create discipline-based and interdisciplinary curriculum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Use instructional strategies that promote active student learning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Use a variety of assessments (e.g., observation, portfolios, tests, performance tasks, anecdotal)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
records) to determine student strengths, needs, and programs.

10. Design more effective hands-on chemistry techniques to students

Q3.2 How well prepared do you feel to do the following?

<table>
<thead>
<tr>
<th>Understand Learners</th>
<th>Notwellprepared</th>
<th>Prepared</th>
<th>Wellprepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand how students’ social, emotional, physical, and cognitive development influences learning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Understand how students’ family and cultural backgrounds may influence learning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Identify and address special learning needs and/or difficulties</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Teach Critical Thinking and Social Development

<table>
<thead>
<tr>
<th>Teach Critical Thinking and Social Development</th>
<th>Notwellprepared</th>
<th>Prepared</th>
<th>Wellprepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Develop students’ questioning and discussion skills.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Help students learn to think critically and solve problems.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Encourage students to see, question, and interpret ideas from diverse perspectives</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Use Technology

<table>
<thead>
<tr>
<th>Use Technology</th>
<th>Notwellprepared</th>
<th>Prepared</th>
<th>Wellprepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase student interest and learning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Support research and analysis (i.e. accessing the Internet)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Assess and track student achievement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Enhance group collaboration and teamwork</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q3.3 -Overall, how well prepared do you feel to teaching?
- Not well prepared (1);
- Prepared (2);
- Well prepared (3)

Teacher needs for teaching chemistry

Q4.1 Please answer this question regarding your resource needs to improve your teaching practice

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>A little</th>
<th>Neutral</th>
<th>Somewhat</th>
<th>Very</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Analysis and measurement equipment (scale, pH-meter, sensors, etc.)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2. Chemicals</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3. Glassware</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4. Computers</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5. Library at the institution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Laboratory room</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7. Internet access</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>10. Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q4.2 - Using the classification scale, please indicate the degree in which you would be interested in training or professional development designed to….:
<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>A little</th>
<th>Neutral</th>
<th>Somewhat</th>
<th>Very</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Content - Subject Matter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Laboratory skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Classroom management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Effective Teaching Practices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Use of technology in the classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Group Dynamics: Working in Teams</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Articulate the curriculum to essential learning outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Other (please specify):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix F: Interview Questionnaire

Warm up

Objective: To establish comfort and begin to learn about chemistry teacher background.

I would like to learn more about your background as a teacher. Tell me about your educational background.

- What preparation have you had to be a chemistry teacher?
- What are your degrees in?
- How many chemistry classes in college have you taken?
- How long have you taught?
- Where have you taught?
- Do you teach other subjects besides chemistry? Which one? And how is your schedule of the day/year?

Tell me a bit about your students and their needs/backgrounds.

- Are they from rural/urban areas?
- Do they come from low/high income homes?
- Do they have any science background?

Awareness and general knowledge of teacher preparation and needs

Objective: To determine what preparation and professional development opportunities chemistry teachers have. Identify chemistry teachers’ needs and potential concerns, if any, related to challenges teaching diverse students.

Now tell me about your teaching preparation

- Do you feel that your preparation gave you pedagogical tools for teaching chemistry?
- What kind of tools have been the most effective?
- Do you feel prepared to teach your students about the science process skills such as observation, communication, classification, inferences, and predictions?
- Do you feel prepared to teach your students about the nature of science: "Scientific knowledge is tentative (subject to change)", "Science is empirically based", and "Science is inferential, imaginative and creative"?
- Do you feel that your training provided tools for incorporating technology into your educational practices?
- Did you take a course as part of your professional development to use technological tools in the classroom?
- Do you feel well prepared to teach laboratories about chemical equilibrium, thermodynamics, basic principles of matter and energy, chemical compositions, solutions and solubility, acid-base chemistry?
- Do you feel prepared to teach your students about laboratory safety?
- Do you attend any professional meetings of teachers?
-Do you read any magazines or journals about teaching in general? About teaching chemistry?

I would like to know about the difficulties you perceive when teaching diverse students.
-What are the main problems that you have teaching diverse students?
-Do you feel that you are prepared to teach students with learning disabilities?
-What factors do you think influence what students learn in chemistry?
-Do you feel that you are prepared to deal with a heterogeneous population of students? Why yes/no?
-Do you think that the teacher is the main source of motivation for better student learning? Why yes/no?

Tell me about your professional development experiences.
-Have you taken any professional development classes this year? If yes, please describe them.
-If you could take more professional development in the future in what topics would be the most helpful to you as a teacher?

I would like to know about your needs when comes to teaching chemistry
-What are the main difficulties you face when it comes to teaching? For example, at the institutional level, at the classroom level.
-What materials do you need for your teaching practices? What technology do you need? Does the institution have sufficient funding to buy instructional materials?

Opinion & perceptions of performance evaluation
Objective: To determine the perception of teachers about the evaluation of their performance by the authorities and the system of promotion roster.
-Do you think "classroom inspections" are the best way to evaluate chemistry instruction?
-How do you think the evaluation should be designed?
-What is your opinion of the current form of grade scaling by your school? How do you think it should be?

Closing thoughts
Objective: To find out any other thoughts that chemistry teacher may desire to add and allow time for final comments.
-What other support would you like to see or receive as a chemistry teacher?
-What else would you like to talk about before we finish?

Thank you very much for your time and insight.