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KNOWLEDGE OF ASSESSMENT: AN IMPORTANT COMPONENT IN THE PCK OF CHEMISTRY TEACHERS

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Abstract

Assessment of learning plays a central role in the teaching-learning process, and it has been extensively investigated due to the recognized necessity of adjusting didactic models to the new curricula and social demands. The knowledge of assessment is considered one of the components of pedagogical content knowledge (PCK) by some authors and for other authors is considered one component of the knowledge base for teaching. It is also recognized the strong link between knowledge of the educational ends, goals, purposes and values and the knowledge of assessment procedures. In this work, results focused on ten chemistry teachers are presented with the main goal of assessing and describing the knowledge of assessment practices and its close relationship with the purposes and educational aims. The results of the current study are based on semi-structured interviews, schools' educational projects, questionnaires, evaluations and teacher lesson plans. The data suggest that there exists an inconsistency in the discourse regarding general education and chemistry education. Although the discourse at all levels, including educational projects, planning and interviews, can be considered as innovative, in actual practice we observed a strong tendency toward the teacher-centered approach and summative assessment. The results show that, in general, the investigated chemistry teachers lack the intrinsic knowledge to elaborate questions that assess students´ higher-order thinking, to use assessment results to improve teaching and learning, to inform planning, and ultimately, to perform assessments for learning that regulate and promote the learning process, in line with their own beliefs regarding the objectives of chemical education. As a result, we can infer problems in other PCK components of these teachers.
Keywords: *assessment, chemistry teacher education, knowledge base of teaching, pedagogical content knowledge.*

Introduction

Classroom assessments and student evaluations are an integral part of the teaching-learning process. The assessment of learning is a complex process and it has been an important subject of research in science education given, in part, its recognized capacity to change curricula. Assessments should be aligned and in accordance with the instructional goals, guide the learning process and stimulate further learning (Bell, 2006; Bennet, 2004; Earl, 2003; Holbrook, 2005; Hume & Coll, 2009; Sadler & Zeidler, 2009; Shwartz, Dori & Treagust, 2013). Assessment methodology is dependent upon the teaching-learning conceptions and may impact student representations of science and student learning of science (Hofstein, Mamlok-Naaman & Rosenberg, 2006). Assessment practices in science education have undergone significant changes in recent decades (Bell, 2006; Klassen, 2006; Hume & Coll, 2009; Shwartz, Dori & Treagust, 2013). Changes in classroom assessment go far beyond incorporating new techniques; the changes represent important shifts in the thinking about learning and teaching and teachers will be expected to be far more assessment literate in the future (Stiggins, 1998; Morine-Dershimer & Kent, 1999). Formative assessment practices as a means of improving student learning have gained importance as alternative perspectives to traditional assessments and can

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be described as a dynamic interaction between teaching and learning, designed to give feedback to teachers planning and guide learning through formal and informal means (Buck, Trauth-Nare & Kaftan, 2010; Russell & McGuigan, 2007).

However, despite the current emphasis on formative assessment strategies, recent research suggests that teachers are implementing only a narrow interpretation of assessment within this perspective, and classroom practices are still dominated by summative assessment procedures designed to assure that students comply with criteria (Shwartz, Dori & Treagust, 2013; Jamison, 2013; Hume & Coll, 2009). Also assessment in schools is influenced by university entrance exams and as a result the teaching focuses on the scientific concepts evaluated on these exams (Fensham, 1993; Corio & Fernandez, 2010; Fernandez, Holbrook, Mamlok-Naaman & Coll, 2013). This is especially true for developing countries where assessment is more likely to be a series of summative tests, further promoting the economic view of chemistry learning over the more democratic approach favouring a broad spectrum of chemistry education gains for all (Fernandez, Holbrook, Mamlok-Naaman & Coll, 2013).

Assessments can take many forms, and assessment activities serve a variety of purposes within the educational framework. Many decisions must be made by teachers when deciding how to assess and evaluate their students' learning, and numerous demands, interpretations, and beliefs influence each decision (Eilks, Rauch, Ralle & Hofstein, 2013). Within the process of student evaluation, teachers must interpret the goals and objectives of the curriculum, determine what data or criteria provide evidence of learning, decide what forms of assessment are most appropriate for collecting data and measuring achievement, decide how these assessments should be weighted when evaluating student learning, and determine how this information will be used in the learning process and communicated to the students (Jamison, 2013).

General approaches of classroom assessment have been described in literature as assessment of learning, assessment for learning and assessment as learning, (Ballester *et al*., 2000; Earl, 2003; Gardner, 2012; Hume & Coll, 2009). These approaches all contribute to student learning but in different ways. Assessment of learning dominates most classroom assessment activities presenting a summative purpose and being intended to certify learning and report student progress. It often takes the form of tests or exams aimed to measure the quantity and the accuracy of student work. Assessment for learning shifts the emphasis from summative to formative assessment. It occurs during the course of a unit of study, and its main purpose is to create data and descriptions that can be used to aid in further learning. Assessment is based on a variety of information sources, so teachers can modify learning for their students. It is an interactive process whereby the teacher provides assistance as part of the assessment. Assessment **as** learning occurs throughout the learning process. It also has a formative nature and emphasizes the active role of the student. Students monitor what they are learning and make necessary adjustments. As can be assumed, the reference points for each type of assessment differ considerably. In the traditional approach of assessment of learning, individual performance compares to other students. In assessment for learning, the reference points are the identified external standards or expectations. Finally, in assessment as learning, the main references are the student's own prior work and targets for continued learning. In addition, the roles of the students and teachers vary depending on the assessment approach being implemented. While the teacher is the key assessor in the assessment of and for learning, the student plays the central role in the assessment **as** learning approach.

According to Gardner (2012), the use of the term "assessment for learning" is more appropriate than the technical term "formative assessment" and it is defined as:

> the process of seeking and interpreting evidence for use by learners and their teachers, to identify where the learners are in their learning, where they need to go, and how best to get there.

In terms of classroom practice, it reveals a complex weave activities involving pedagogical style, student-teacher interaction, self reflection (teacher and student), motivation and a

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variety of assessment process (Gardner, 2012). The author tried to analyze the complex learning approach, presenting ten principles of assessment for learning as the following: is part of effective planning; focuses on how the students learn; is central to classroom practice; is a key professional skill; is sensitive and constructive; fosters motivation; promotes understanding of goals and criteria; helps learners know how to improve; develops the capacity of self-assessment; recognizes all educational achievement.

Knowledge of Assessment as One of Knowledge Base for Teaching and as a PCK Component

Teachers engage in a broad range of assessment roles. Knowledge of assessment of science learning can be regarded as one of the central components of a teacher's pedagogical content knowledge (PCK) (Fernandez, 2011, 2014; Fernandez & Goes, 2014; Kind, 1999; Schneider & Plasman, 2011).

According to Magnusson model, PCK can be described as the combination and interplay among five components (Figure 1).

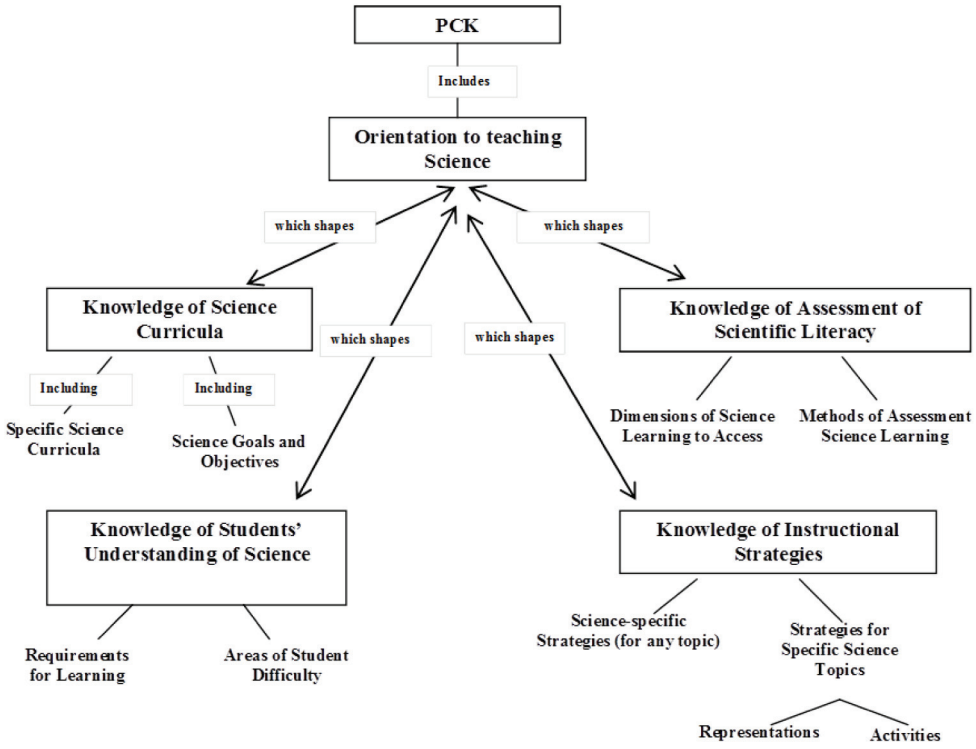

Figure 1: Components of Pedagogical Content Knowledge for Science Teaching.

From: Magnusson; Krajcik & Borko, 1999, p. 99.

In this model PCK includes the orientations to science teaching that shape the other components: knowledge of science curricula, knowledge of students' understanding of science, knowledge of instructional strategies, and knowledge of assessments of science learning (Magnusson, Krajcik & Borko, 1999). In the model of teacher knowledge from Grossman (1990) assessment is considered part of one of the components of PCK - knowledge of instructional strategies.

Morine-Dershimer and Kent (1999) present a model that shows their interpretation of the

place of pedagogical knowledge in respect of all categories of teacher knowledge identified by Shulman (1987) and emphasize three points (Figure 2).

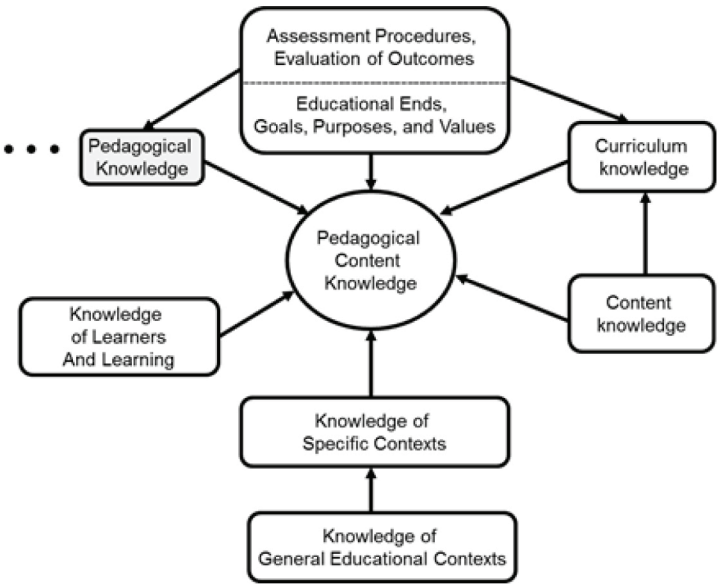

Figure 2: Categories contributing to Pedagogical Content Knowledge.
From: Morine-Dershimer & Kent, 1999, p. 22

One is the close relationship between the aims and purposes and their inseparability from knowledge about assessment processes. Another is that curriculum knowledge is powered by both the content knowledge and the knowledge of goals / assessment processes. And yet in the model only the category knowledge of general contexts is directed to a subcategory of knowledge of specific contexts, but each of the other categories are directly related to pedagogical content knowledge, that means, knowledge of the specific content, knowledge of the specific curriculum and knowledge of objectives / assessment procedures of specific pedagogy and specific students. (Morine-Dershimer & Kent, 1999). For these authors, therefore, the PCK consists of six knowledge: i) knowledge of the purposes and educational objectives linked directly to knowledge of assessment procedures; ii) pedagogical knowledge; iii) curriculum knowledge; iv) content knowledge; v) knowledge of specific contexts; and vi) knowledge of learners and learning.

This work specifically focuses on high school chemistry teachers' knowledge of assessments of science learning. While the above mentioned dimensions are obviously not mutually exclusive, they can be regarded as distinct components that describe PCK (Park & Oliver, 2008). In particular, the PCK component related to the knowledge of assessment includes, among others, knowledge of which dimensions of science learning are important to assess and knowledge of the methods by which science learning can be assessed.

In respect on assessment specifically in the context of chemistry education Danili and Reid (2005) focused on the relationships among the results of various formats of classroom chemistry assessments and what the different formats of the assessment were testing. Bennet (2004) investigated how well examinations are used by chemistry teachers as a measure of claimed learning outcomes while Vázquez-Bernal *et al*. (2013) described a case study focused on the evaluation of a secondary education science teacher, addressed from two different approaches: action-oriented reflection and classroom action itself.

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According to Earl (2003), for appropriate assessment of students' learning, teachers need to use their personal knowledge of the students and their understanding of the curriculum in the context of the assessment. Therefore, assessment practice depends on the integration of different domains of knowledge in a process that may increase teachers' efficacy.

The aim of this study is to investigate the assessment component of student learning on chemistry teachers´ PCK. The investigation also discusses how teachers' knowledge of assessment practice articulates and supports the other central PCK components, especially the orientation towards science teaching. This component represents "a general way of viewing or conceptualizing science teaching" (Magnusson, Krajcik & Borko, 1999, Figure 1) referring to teachers' beliefs about the purposes and goals for teaching science. It, therefore, holds a strong influence in PCK construction by guiding the instructional decisions, the use of curricular materials, the choices of instructional strategies, and the assessments used to measure student learning (Borko & Putnam, 1996; Hofstein & Eilks, 2013). The PCK component "orientation towards science teaching" from Magnusson, Krajcik and Borko (1999) model is related to the "conceptions of purposes for teaching subject matter" from Grossman´s model (1990) and also to the "educational ends, goals, purposes and values" from the Morine-Dershimer & Kent model, Figure 2).

The current study is based on the analysis of semi-structured interviews and includes documents produced by teachers and the schools where they work, including the teacher's annual instructional plans, the school´s educational projects (named in Brazil political pedagogical projects, PPPs) and the nature of the exam questions in the applied evaluations. Many aspects of PCK are visible in a teacher´s instructional planning. In this work, teacher lesson plans were investigated since these documents offer an important resource for capturing many aspects of the teacher's PCK. It was investigated the general content of the planning specifically related to assessment as well as the more general features related to teachers' perceptions towards general education and chemical education.

To systematically describe facets of assessment knowledge on chemistry teachers' PCK, this study investigated the knowledge that teachers have of assessment methods and instruments, their understanding of classroom assessment functions and purposes in the teaching and learning process, their understanding of students' learning evidences, uses of assessment results and the nature of the questions they use in formal exams. Also, the teaching-learning conceptions upon which these teachers base their principles of evaluation were investigated. The study addressed questions related to how chemistry teachers make decisions about the ways in which they assess student achievement and what factors are considered in these decisions. Thus, the aim of the study is to contribute to the understanding of chemistry teachers' knowledge of assessment practices, their awareness of the different factors that inform teachers' decisions and their practice in conducting classroom assessments and student evaluations.

Methodology of Research

Participants and Setting

The results from this research are focused on the assessment practices of ten chemistry high school teachers practicing in public and private schools and enrolled in a chemical education master's degree program at the University of São Paulo. A description of the participating teachers is briefly presented in Table 1.

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Table 1. General characterization of the investigated teachers (T).

Teachers	Education and Characteristics
T1	Has a degree in chemical engineering and three years teaching experience in a private school.
T2	Has a degree in industrial chemistry and chemistry teacher education and fifteen years teaching experience in a public and private schools.
T3	Has a degree in food engineering and fourteen years teaching experience in a public and private schools.
T4	Has a degree in science and science teacher education for fundamental school and is in the first year of teaching in a public fundamental school.
T5	Has a bachelor degree in chemistry and chemistry teacher education and three years teaching experience in public and private schools.
T6	Has technical formation in nursing school and chemistry teacher education and five years teaching experience in private schools.
T7	Has a degree in chemistry teacher education and ten years teaching experience in public and private schools.
T8:	Has a degree in chemistry teacher education and two years teaching experience in public school.
T9	Has a degree in chemistry teacher education and five years teaching experience.
T10	Has a major degree in science with habilitation in chemistry and pedagogy and nine years teaching experience in public and private schools.

Instruments and Methods of Analysis

The current study is based on the analysis of the following materials: *i)* semi-structured interviews, *ii)* annual instructional plans and schools´ political pedagogical projects, and *iii)* written evaluations (exam questions).

i.) Interviews

Semi-structured interviews were structured around the following main questions:

1. Make a brief report about your educational trajectory and your experience as a chemistry teacher.
2. In your opinion, what is important for students to learn in your course?
3. How do you know if the student has acquired knowledge in your course?
4. What is the organization and process of assessment? How do you plan assessment?
5. What experiences in assessment do you have in your teaching practice?
6. What are the most frequently used assessment tools and how are they applied?
7. What is a participation grade? (Question added by being present in most discourses of teachers)
8. What values are assigned to each instrument?
9. Describe the criteria for approval in your course.
10. Does the assessment practice as well as its criteria follow some guideline or do you have total freedom in your decisions?
11. Are such criteria discussed with your students? At what point in the process? What is done with the results?
12. In your opinion, what is the purpose of assessment in chemistry? What is (are) its role(s)?

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The interviews were audio-recorded, transcribed integrally and analyzed. The answers to the interviews were categorized and related to a teacher-centred model as well as discovery learning and student-centred models.

According to its functions, the assessment was classified as having a social or a pedagogical nature. The social character of each assessment practice was characterized by the functions of verify, qualify, certify, or select. The pedagogical nature included the function of regulating the learning process and referred to changes that teachers should introduce in their teaching process and that students should embrace in their learning process.

In order to describe the assessment strategies, we investigated the specific instruments used by the teachers, the time that the assessment was carried out, and the nature of the questions used to probe students' learning.

ii.) Annual Instructional plans and Schools' Educational Projects

Many aspects of teachers´ PCK can be identified in instructional planning. The analysis of schools' educational projects or as named in Brazil, Pedagogical Political Projects (PPPs) and teachers' instructional plans aimed to describe which teaching-learning conception guides the practice of the investigated teachers. One of the goals behind the analysis of such documents was to verify the coherence (or lack thereof) between what the school considers important and the teachers' concepts and plans.

PPPs and instructional plans were categorized according to different curriculum emphases and grouped into two categories: "General Education" and "Chemical Education" (van Driel, Bulte & Verloop, 2005). Such emphases are also classified into sub-categories that have been suggested by the literature. "Chemical Education" consists of three emphases: *Fundamental Chemistry* (FC), *Chemistry, Technology and Society* (CTS) and *Knowledge Development in Chemistry* (KDC). "General Education" consists of the following six emphases: *Career, Discipline, Product, Pedagogy, Democracy* and *Process* (Denessen, 1999; van Driel, Bulte & Verloop, 2005). These emphases are described as:

Pedagogy: the importance of students' personal development
Democracy: valuing students´ opinions and desires
Process: the importance of the learning process
Career: preparing students for a future career
Product: emphasizing achievement
Discipline: obedience, order and the will to work

These categories were used to evaluate the curricular emphasis that dominated the schools´ PPPs and that the teachers assigned to the teaching process in their plans. In this work, five PPPs and six instructional plans were investigated.

iii.) Written evaluations

Twenty-one formal exams were analyzed, providing a total of 136 questions. The exam questions were classified as reproductive and productive in accordance with Enero (1998), Sanmarti and Alimenti (2004) and Sanmarti (2007). Reproductive questions evaluate what the student recalls. Productive questions are intended to ensure that the student knows how to apply new knowledge in analysis and interpretation of phenomena that are different from those previously studied (Sanmartí, 2007).

The following questions exemplify reproductive and productive questions:

Reproductive questions: *a)* The melting point of a substance is 17°C, and its boiling point is 38°C. Which is the physical state of this substance at 25°C? *b)* Mothballs, a substance used to prevent cockroaches and other insects in clothing, melt at temperatures above 80°C. Mothballs at ambient temperature are constantly reducing their masses, eventually disappearing. What is the name of the process that occurs at room temperature?

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Productive questions: *a)* Relate the topic of your research with the preservation of the planet and/or sustainable development and/or the quality of life and/or better use of the environment. *b)* Review the following statement: "no chemistry, swimming pool treatment." Is it correct? Justify your answer. *c)* Two vials contain white odorless powders. One of them is sodium chloride, and the other is sugar (sucrose – $C_{12}H_{22}O_{11}$). Receiving the recommendation of not testing the flavor of the substances, describe a procedure to identify the contents of each bottle.

Features of PCK Regarding the Assessment of Students' Learning

Different dimensions of teachers´ PCK with respect to assessment were inferred from teachers' answers to the interview questions, their tests and their annual instructional plans. The main dimensions analyzed were: knowledge of instructional strategies, teachers' understandings of the functions and goals of assessment within the educational system, the evidence of learning that guides teachers´ decisions, and the nature of questions developed by the teachers. Table 2 systematically describes the framework developed to analyze teachers´ PCK component related to their knowledge of assessment of learning.

Table 2. Features associated with the PCK component related to teachers´ knowledge of assessment of learning.

Knowledge of Assessment of Learning		
Features	Description	Characteristics
Dimensions of learning	Core concepts	
	Skills	
Instruments	Formal examinations	Written exams
	Non-formal examinations	Oral questions
		Activities
		Behavior observation
Types of Questions	Productive	Assessment of higher order skills
	Reproductive	Assessment of lower order skills
Function	Social	Verifies, qualifies, certifies or selects
	Pedagogical	Regulates and promote the learning process
Moment	Initial	Diagnostic function
	During	Regulatory function
	Final	Certificatory function
Evidence of learning	Performance in formal tests	
	Oral questions	
	Research/report	
	Problem solving skills	
	Behavior observation	
Use of results	Teacher centered	
	Student centered	
Assessment goals	Summative	Certifies learning
	Formative	Emphasizes the role of the student, supports and guides the learning process
Assessment planning	Traditional	Career, product and discipline emphases: prepares students for a future career; emphasizes achievement; and focuses on obedience, order and the will to work.
	Innovative	Pedagogy, democracy and process emphases: values students' personal development, opinions and desires and supports the learning process.

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Results of Research

Using the analysis of the teachers´ interviews, certain aspects of their assessment practices were described as well as certain aspects regarding their orientations to science teaching and learning.

Knowledge of Assessment Practice from Teachers´Interviews

Knowledge of assessment of science learning is a PCK component that comprises features such as knowledge of which dimensions of science learning are important to assess and knowledge of the methods by which that learning can be assessed, such as knowledge of specific instruments, approaches, and activities (Magnusson, Krajcik & Borko, 1999). In this context, knowledge of assessment can be regarded as a combination of teachers´ understanding of the functions assessment, their knowledge of assessment strategies, their views with respect to learning evidences, how they use the assessment results, and the nature of the exams they produce (the types of questions students are asked in the formal written exams). These dimensions of the assessment component of teachers' PCK are systematically discussed next.

Assessment functions. Teachers' understandings of the functions of evaluation within the teaching-learning process and their knowledge of the various assessment strategies strongly influence their choices. We start our analysis by describing teachers' understandings of assessment functions and their relation to the main strategies teachers employ in classroom evaluation.

Assessment has many functions. At times, these functions support one another, and at other times, they compete or even conflict with one another (Earl, 2003). With respect to the main purposes assigned by the teachers to assessment in chemistry education, teachers' views were grouped into two broad categories - social and pedagogical. Social functions include the summative functions that characterize the "assessment **of** learning" approach. Pedagogical functions are more in line with a formative nature of assessment practice, characteristic of the assessment **for** or **as** learning. Table 3 suggests that teachers in this study assign stronger value to social functions of evaluation than to pedagogical functions.

Table 3. Teachers´ views of the main functions of student evaluation.

		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Social Function	Certification (register, document, bureaucracy)	X		X	X	X	X	X	X	X	X
	Motivation to study for a grade	X		X		X	X	X			X
	Punishment	X			X	X		X			
	Classification and differentiation	X						X			
Pedagogical Function	Evaluate student's knowledge	X	X				X	X			
	Provide an opportunity for student learning		X		X						
	Identify clues about knowledge acquired by students				X						

The majority of the teachers (90%) agreed that a major purpose of evaluation is to provide a record of academic standing, thus acting as a certification for students, families and school. It is seen as an especially important document for the school. Also, some emphasis is placed on comparing students by using assessment performance for classification or differentiation. Thus, assessment grading is used to designate the students' position within the group.

Another function of assessment identified by teachers in the study within the social category was that of a motivational (students would be encouraged to study in order to acquire a good grade) or punishing instrument.

Social functions of assessment can be inferred, for example, from the following quotes:

> T6: [...] but I need to apply an exam for bureaucratic reasons. (...) I apply the test as a mere bureaucratic issue and this is required, the school requires that I apply a test that contains that specific content and at the end of the year will have a final exam with an award.
>
> T3: [...] the assessment is a record, a document that the school needs, the student needs to acquire a grade...

The pedagogical functions of assessment were also recognized by this group of teachers; however, the emphasis on these functions is far less. The pedagogical functions considered include determining how much of the curriculum students have mastered, accessing the data on the knowledge acquired by students and supporting student learning by providing an opportunity for learning (mentioned by two teachers).

Assessment instruments and evidence of learning. Next, it describes the instruments used by the teachers to evaluate students' learning and teachers' understanding of what the evidence of learning should be. The aim was to understand what learning evidence guides teachers' choices of evaluation strategies.

The obtained results (Table 4) show that the more extensively used assessment strategies are formal exams and oral questions. The written exam is relatively easy to grade consistently, and it is, therefore, considered the systematic approach for determining students' final grades due to its alleged neutrality and objectivity, thus minimizing discussion and debate. The formal written exam is accepted as the main evaluative activity, and it is the most widespread assessment used by the teachers participating in this study. Oral participation is also evidenced as an evaluation strategy of great importance by teachers though it appears to bring a subjective component to the assessment practice.

Table 4. Instruments used for classroom assessment.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Formal exams	X	X	X	X	X	X	X	X	X	X
Oral questions	X	X	X	X	X		X			
Research/report	X			X	X		X			
Behavior observation	X			X						
Questions (in class or home) and problem solving skills	X									X

Results, therefore, indicate that teachers' practices reflect a dominant preference for formal examinations as opposed to non-examination-based assessments. Therefore, teachers value most the characteristics of formal examination, which allow for verification of student work and are relatively easy to administer and grade consistently (Bennet, 2004). Non-examination-based assessment such as behavior observations and problem solving skills were rarely mentioned. The latter may present some complementary functions when compared to formal examinations that assess a wider range of skills and knowledge over an extended period of time.

Teachers' understanding of the evidence of learning was also analyzed. This knowledge is an important aspect because it guides teachers' choices of evaluation strategies. The obtained results are summarized in Table 5.

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Table 5. Main evidences of students´ learning.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Performance in formal exams	X	X	X	X	X	X	X	X	X	
Oral questions			X	X	X	X	X		X	X
Research/report			X	X	X	X	X		X	X
Problem solving	X			X						
Behavior observation							X			
I don´t know	X		X							

Table 5 shows that the main evidence of student learning is the performance on formal written exams that evaluate conceptual knowledge. The capacity for verbal expression of ideas is also considered an important source of learning evidence and is strongly valued by most teachers.

A combined analysis of the results presented in Tables 4 and 5 shows a strong correlation between teachers' choices of assessment instruments and their understandings of learning evidence. Thus, the conclusion is that the methods by which the investigated teachers choose to assess and evaluate students´ progress and learning is strongly influenced by what they believed the learning evidence to be and their understanding of the purposes of evaluation.

Planning assessments. Teaching plans are also an important instrument for capturing aspects of teachers' knowledge of assessment of learning. It was observed that the general content of the planning specifically related to the assessment is mainly related to the choice of an assessment instrument. Next, we report teachers' answers with respect to the aspects of assessment that were considered in their teaching plans. Teachers' plans of assessment were grouped into the categories presented in Table 6.

Table 6. Teachers' responses regarding the planning of assessments.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Formal exams	X	X	X	X	X	X	X	X	X	X
Oral questions	X	X	X		X		X		X	
Research/report	X			X	X	X	X	X		X
Behavior observation	X						X		X	X
Questions	X									X

Teachers' knowledge of assessment practices is revealed in their teaching plans. Therefore, it was investigated the content of the teaching plans in relation to assessment to describe what features are present. It was also aimed to verify if the assessment practice performed by the teachers is planned, and if so, how this planning occurs. In this regard, most teachers declare that they somehow plan their assessments and that the planning is more associated with the choice of instrument than with any other feature. Teachers select from among those evaluation strategies they believe most important and appropriate within their context. The written exam appears to be the primary evaluation model they use while other strategies are used in a complementary fashion, often as a routine. Seven of the ten teachers claim to use other evaluation in-

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struments such as research or a report. These strategies are always complementary to the formal written exam, and as such, they do not play a fundamental role as an assessment instrument.

The moment of assessment. Analysis of the moment in which assessment is carried out is relevant when determining teachers´ understanding of how the assessment fits into the teaching and learning process.

Regarding the moment when the assessment is conducted, evaluation can be classified in the following categories (Sanmartí & Alimenti, 2004). i) The initial evaluation collects information on previous knowledge as well as the intuitive procedures the student uses to learn and to communicate and the work habits and attitudes of the student at the beginning of the teaching-learning process. The purpose of the initial evaluation is to adjust the teaching-learning process to meet the need of the students, thereby serving a diagnostic function. ii) Evaluating the students throughout the process allows for the detection of obstacles students encounter during the process of knowledge construction. iii) Evaluating the students at the end of the process identifies the learned knowledge as well as determines the quality of the process of education for one given didactic unit. It subsidizes the planning of proposals that aim to improve the teaching-learning process.

In analyzing the moment at which the assessment is carried out, the results suggest strong homogeneity because all the investigated teachers' assessments occurred only at the end of the process. None of the teachers suggested that assessment would also be carried out at the beginning of the learning process or throughout the process. The assessment was carried out every month or every two months, and such periodicity was typically imposed by the school system. The results are consistent with the assessment of learning approach, where the assessment is typically completed at the end of a unit, course, period, or program and takes the form of assessments that include questions from the material studied during a specified period of time. When assessment is used in a more formative approach, assessment often occurs in the middle of the learning process and often more than once rather than being conducted only at the end.

The analysis thus shows that for this group of teachers the tests have only a certificatory function because they are applied at the end of each didactic unit. T1 and T2 claim they apply tests during the process, but data analysis reveals that, in reality, these are summative evidences distributed in smaller intervals, and they do not correspond to a regulatory assessment during the process.

The use of assessment results. Assessment results can be used in a variety of ways to improve teaching and learning and to inform planning. Assessment results can be especially valuable in helping teachers monitor their instructional practices and find strategies to meet the needs of individual students (Jamison, 2013). Table 7 reports teachers´ strategies when students perform poorly on an assessment.

Table 7. Teachers' responses regarding the uses of assessment results.

		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Focus on the student	Maintain the final score		X	X	X	X	X	X	X	X	X
	Review the content and redo some questions	X		X			X			X	
	Propose new questions		X								
	Apply a new test	X									
	Include a participation grade					X					X
	There is no feedback from the assessment to the students		X		X	X				X	X
Focus on the teacher	Replanning	X			X					X	
	I am called by the coordinator							X			

The teachers' responses were initially classified into two categories that relate to different focuses on performance evaluations: the teacher and the student. The data in Table 7 suggest that for the teachers in this study, responsibility for the performance on assessments rests mainly on students. When the teachers were asked how they deal with the results on assessments, their answers were directed predominantly at students' poor performances. The analysis of teachers' initiatives when facing students' poor performances on tests suggests that teachers consider the student as the one responsible for the poor results.

In some cases, the teacher revises the specific content to be assessed and works on solving new exercises (four out of ten teachers). The implied idea is that poor performance is due to poor understanding of how to solve exercises and that students will learn by repeating the same exercises. Students' accountability for their poor performance is consistent with the traditional teaching and learning perception.

It is worth mentioning some strategies implemented by the teachers to address students' poor performance, which should be reflected upon from a pedagogical point of view. These strategies include: awarding a participation grade to improve the final grade (suggested by two teachers) and administering a new test to masquerade the final result. It is possible that, the pressures from the community and the school cause the teacher to ignore the need for a real investigation of students' performance to negotiate an acceptable final result.

Ideas associated with the feedback of evaluation of results – an important moment in the discussion and interpretation of results obtained by the students – have not been observed in the teachers' declarations. The feedback presented was based on the fact that at least the low-performing students had the opportunity to review the exams and work on the exercises again with assistance from the teacher. Although this approach is not, in our view, the most appropriate way to provide proper feedback, it was the only initiative reported. Because the students are commonly denied the opportunity to review the exam, this initiative is considered positive, pointing to the potential for change, although small, to make assessment clearer and more transparent to the learner.

Nature of proposed questions. Another important source of information regarding teachers´ knowledge of assessment is the type and nature of exam questions teachers write for the formal exams. In this respect and in the specific context of chemistry, it is relevant to mention the work of Sanabria-Ríos and Bretz (2010), who investigated teachers´ expectations about learning chemistry and the influence of those expectations on the writing of exam questions. Results from their research suggested that the type of exam questions written by teachers is strongly influenced by the instructional objectives and the cognitive expectations associated with learning chemistry. Consistent with the topic-dependent nature of PCK, this study found that the distribution of exam questions from lower-order to higher-order is dependent upon the nature of the investigated chemistry topic.

A study of the tests produced by the investigated group of teachers was carried out. The types of questions produced by the teachers, and the types of skills these questions assessed were analyzed. It would be desirable that science knowledge exceeds rote memorization of facts, equations, and procedures and that it contributes to the development of an applicable and contextualized knowledge. This idea suggests that science teaching should value the development of higher-order thinking skills. The transition from traditional algorithmic lower-order cognitive skills (LOCS) teaching to higher-order cognitive skills (HOCS) learning in science requires a simultaneous and aligned shift in student assessment (Lubezky, Dori & Zoller, 2004; Zohar, & Schwartzer, 2005). It is, therefore, desirable that teachers develop the requisite knowledge to produce HOCS-promoting assessment practices, which are intended to enhance students' evaluative thinking. Thus, teachers' learning expectations should correlate with the algorithmic or conceptual nature of applied evaluations. From such a perspective, it is relevant to investigate whether higher-order thinking skills are being valued in assessment practices.

We analyzed the proposed formulations of exam questions and related them to didactic models. We analyzed 136 questions from 21 teacher-prepared exams and classified the ques-

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tions as reproductive or productive. These categories are related to LOCSs and HOCSs, respectively. The results are shown in Table 8.

Table 8. Results obtained for the categorization of exam questions (N = number of questions analyzed for each teacher).

	T1 N=8	T2 N=8	T3 N=5	T4 N=3	T5 N=8	T6 N=55	T7 N=26	T8 N=0	T9 N=12	T10 N=11
Reproductive questions (%)	50	50	100	100	87	73	92		58	100
Productive questions (%)	50	50	0	0	13	27	08		42	0

Table 8 shows that the vast majority of the questions formulated by the teachers for written exams are classified as reproductive questions and were thus related to assessing students' traditional algorithmic lower-order skills. This result suggests that teachers' tests tend to encourage rote and superficial learning.

Although teachers have the freedom to decide the nature of the questions in the exams they administer, the nature of questions they produce offered evidence that there is an absolute predominance of questions based on direct application of memorized concepts. This reinforces the idea that the assessments produced and administered by the investigated group of teachers are based on a transmission/assimilation concept of teaching-learning. This contradicts the assertion by many of these teachers that they do not support this form of learning.

> T5: [...] in fact, I do not consider important to memorize concepts, nor does it mean the student has learned... He may memorize that for the test and on the next day, if you ask the same question, he does not know anymore, since he had memorized, and just forgot.

Despite such claims, reproductive questions were the primary type of questions developed by the teachers. It is possible that the origin of this behavior may be rooted in a lack of knowledge on how to create questions that encourage students to integrate and construct meaningful knowledge relationships rather than the teacher's decision to only develop reproductive questions. The nature of the questions elaborated by the teachers appears to contradict their beliefs. The elaboration and grading of productive questions presents a greater challenge to teachers.

The analyzed data further show that teachers make extensive use of questions in textbooks, thus avoiding having to produce their own questions that would be more in line with their beliefs and their students' needs.

Therefore, the analysis of the exam questions formulated by the teachers points to a prevalence of questions that require students to repeat or remember concepts without much elaboration. These questions mainly ask for definitions and examples. A systematic and detailed analysis of the questions that compose the formal exams reveal significant valuing of the chemical content rather than valuing those aspects related to the abilities, skills and attitudes.

Lacking the intrinsic PCK component to elaborate questions that probe the conceptual nature of chemistry and promote conceptual learning, teachers are constrained to use merely reproductive questions or to copy questions form textbooks (which are also extremely reproductive in nature). Therefore, it was concluded that the investigated teachers lack the necessary PCK component regarding to knowledge of assessment to promote and assess students´ higher-order thinking.

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The Goals for Chemistry Teaching and the Importance of Chemistry in Secondary Education: Aspects of Orientations to the Science Teaching Knowledge Domain

PCK for effective teaching depends on the integration of different aspects of teacher knowledge in highly complex and consistent ways. Teachers´ orientations to science teaching and learning are expected to strongly influence teachers as they decide how to conduct classroom assessments and student evaluations. Such a PCK component is related to teachers' beliefs and understandings about general aspects related to education, from their perceptions with respect to the goals of science education at different educational levels, to the nature of science itself, and to their beliefs about the ideal theoretical perspectives for teaching of science. In the context of the present study, special emphasis was given to teachers' understandings of the main goals for teaching chemistry and the importance of chemistry in secondary education. Teachers' views in this regard were compared to the approaches that are present in the Brazilian official guidelines because personal practical knowledge and beliefs of teachers exert a major influence on the way they respond to the aims of the federal guidelines and the prescribed curriculum. It is, therefore, relevant to compare teachers' personal views and the recommendations in the official documents.

The competencies and abilities to be developed within each area of learning can be described as the structural base for the Brazilian National Curriculum Parameters (PCNs+). The guidelines in the PCNs+ aim to focus more attention on the relations between science and society and on the understanding of the nature of science and scientific knowledge. Further, the guidelines aim to increase student awareness of the ways in which scientific knowledge is produced and developed in addition to the traditional focus on the understanding of the academic content of chemistry.

Teachers' views of aspects related to the goals for teaching chemistry and the importance of chemistry in secondary education were classified according to the orientations in the National Curricular Parameters for chemistry education in high school (Brasil, 2002) and include the following: a) chemistry knowledge as a tool to understand the world; b) the understanding of science, its concepts, methods and language; and c) the understanding of science as an historical construct related to technological development and many aspects of society. These categories are closely related to the ones proposed by van Driel, Bulte, and Verloop (2005) to classify curriculum emphasis on "Chemical Education." Analysis of the interviews according to the orientations in the National Curricular Parameters categories led to the results shown in Table 9.

Table 9. Categories for analysis of teachers' understanding of the goals for teaching chemistry and the importance of chemistry in secondary education. Teachers' views regarding the main goals related to chemical education.

National Curricular Parameters (PCNs+) (Brasil, 2002)	Curriculum emphasis on "Chemical Education" (van Driel *et al.*, 2005)	Teachers
Chemistry knowledge as a tool to understand the world	Chemistry, Technology and Society	T1, T2, T4, T5, T7, T9, T10
The understanding of science, its concepts, methods and language	Fundamental Chemistry	T2, T3, T4, T5, T6, T7, T8, T9
The understanding of science as an historical construct, related to technological development and many aspects of society	Knowledge Development in Chemistry	T1, T2, T4, T7, T9

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The qualitative analysis of the results shown in Table 9 indicates that the majority of the teachers in this study are well aware of the basic ideas that orient the federal guidelines and the prescribed curriculum for chemistry education in Brazilian official documents. The three approaches that were recommended in this document are considered together by four of the interviewed teachers.

Analysis of Political Pedagogical Projects and Instructional Plans

Instructional plans developed by the teachers can be valuable sources for gathering information regarding many aspects of teachers' perceptions and knowledge. In fact, important features of a teacher´s PCK are identifiable in his/her instructional planning. In this work, an analysis of instructional plans was performed according to two distinct perspectives: first, those aspects directly related to teachers´ knowledge of assessment of learning and second, the general perceptions regarding education, and more specifically, chemistry education that emerges for their plans.

The instructional plans produced by the teachers and the school's PPPs were analyzed and categorized according to the instrument proposed by van Driel, Bulte and Verloop (2005) considering general education and the chemistry curricular emphasis. In this context, a curricular emphasis is defined as a teacher's understanding of the objectives to be achieved. For each of these aspects, different structures can be identified. The first one combines curriculum emphasis on Fundamental Chemistry (FC) with an educational concept centered mainly on the content. The second one combines the curricular emphasis Chemistry, Technology and Society (CTS) and Knowledge Development in Chemistry (KDC) with an educational concept that is more student-centered. Likewise, considering those aspects that are more specific to general education, the emphasis on Career, Discipline and Product is related to the traditional teaching and learning view while the Pedagogy, Democracy and Process emphasis suggests a more innovative teaching perspective. In this work, these structures were used to identify the teaching concepts that emerge from PPPs and instructional plans. Table 10 reports the categories and curricular emphases that were identified in the analysis of these documents.

Table 10. Analysis of political pedagogical projects and instructional plans according to *General Education* and *Chemistry Education*.

		Political Pedagogical Projects	Instructional Plannings
General Education	Career	T1	
	Discipline	T5, T9	T1
	Product	T1	T9
	Pedagogy	T1, T2, T3, T5, T9	T1, T2, T5, T9
	Democracy	T1, T2, T5, T9	T9
	Process	T5, T9	T9
Chemistry Education	Fundamental Chemistry	T1, T5	T2, T3, T5, T7, T9
	Chemistry, Technology and Society	T5	T1, T5
	Knowledge Development in Chemistry	T1, T5	T1, T5
Functions	Social		T2, T3
	Pedagogical	T1	

Although the number of documents analyzed was small, the results provide valuable information. The analysis of the PPPs regarding general education suggests an innovative teaching concept. However, the evaluation to be carried out was specifically mentioned only on the PPP for Teacher T1. The evaluation suggests a pedagogical function, which is consistent with the proposed objectives in general education.

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Curricular emphasis in Chemical Education was specifically mentioned in only two of the analyzed PPPs, the schools of T1 and T5. In both cases, these PPPs combine traditional and innovative concepts. In the PPPs from the schools of T2, T3, T5 and T9, evaluation is not mentioned, suggesting that the teaching proposals are linked with an innovative design, but there is no formal orientation on how assessment in light of this concept should be practiced, thus suggesting a freedom of choice for the teachers. These documents do not offer an orientation on how assessment could be effectively and coherently aligned with such innovative teaching-learning concepts.

Thus, in the five investigated PPPs, innovative educational concepts emerge. Analysis of teaching plans reveals innovative concepts regarding General Education and traditional concepts regarding Chemical Education and the functions of assessment.

The concepts those are presented in the teaching plans within the context of assessment and as expressed in each case reveal that, considering aspects related to General Education, innovative concepts are dominant and evident in all cases. Special importance is given to a curricular emphasis on pedagogy, suggesting a concern for students' personal development. This is consistent with those aspects expressed in the PPPs. However, it was found references to an emphasis on traditional concepts such as discipline (focusing on obedience, order and the will to work) and product, which is related to achievement; in this case, achievement manifests itself in the form of good grades.

Considering the concepts related to Chemical Education, the ideas that emerge from teaching plans indicate an emphasis on Fundamental Chemistry, suggesting the importance of chemistry content. More innovative conceptions revealed by the presence of Chemistry, Technology and Society and Knowledge Development in Chemistry were observed in the plans of two investigated teachers (T1 and T5). The predominance of the traditional perspective, as revealed by the investigated plan, may be considered inconsistent with the general goals for teaching that are expressed in the very same instructional plans and the schools' PPPs.

With regard to the functions of assessment, the teacher plans developed by T1, T2 and T3 mention social functions, which may be associated to a traditional teaching perception. T5 and T9 describe in their plans the instruments to be used for assessment, but they do not establish the criteria to be used or when these instruments will be administered.

The above described results indicate that education legislation in Brazil has a significant influence on teachers' perceptions of the chemistry curriculum.

Discussion

Table 11 reunites the main features observed in teachers' practices, instructional plans and PPPs. In this table, the results are organized as related to the assessment of, for and as learning approaches, according to Earl (2003) and the present research.

The way how investigated teachers demonstrate student learning is through their performance on objective evidence. These assessments are applied in monthly and / or bimonthly frequency and this objective has only to divide the amount of content into smaller fractions to facilitate the study of students. Evaluations are typically applied only at the end of the teaching process. The exam is the assessment tool that weighs more in the final statement of the student's grade and the approval criteria takes into account to obtain a minimum required note to be approved. The evaluation criteria are rarely discussed with the students and in relation to unsatisfactory results, the content is taken up with new exercises similar to those assessed first. These results are in line with the ones found by Shwartz, Dori and Treagust (2013). Despite the homogeneity in the use of assessment tools, most teachers indicated having freedom in its decision on the review process.

Understanding regarding the evaluation, for most teachers surveyed, is related to the certifying role. The analysis of the objectives and methodology of the evaluation process proves to be consistent with a teaching practice focused on chemical content and targeted mainly at

transmission / assimilation and suggest that evaluation practiced by them has a role predominantly certifying and it is influenced by universities entrance exams and as a result the teaching is focused on the scientific concepts evaluated on these exams (Fensham, 1993; Corio & Fernandez, 2010; Fernandez, Holbrook, Mamlok-Naaman, & Coll, 2013).

However, the intentions of teachers contrast with such actions and conceptions of teaching and learning inferred from his speeches show is quite consistent with the directions suggested by Brazilian curriculum reforms, expressing models of student-centered learning, and emphasizing aspects related to the enhancement of student development and the learning process. Thus, innovative speeches related to the approaches based on constructivist teaching and learning coexist fairly with traditional practices. This contradiction, however, seems not to be fully understood by teachers. Again, there is a discrepancy between the educational intention and the reality of the classroom. Therefore, it is concluded that with regard to the evaluation, the constructivist discourse is accompanied by traditional practice.

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Table 11. Selected features of assessment *of, for* and *as* learning and the classification of teachers' practices, instructional plans and PPPs.

		Purposes	Instruments	Teachers' and students' roles (key assessors)	Dimensions of learning	Moment	Use of assessment results, feedback to students	References	Curricular emphasis
Traditional	**Assessment *OF* Learning** Summative	**Social** Certify learning; classify; designate students' position in the group; maintain records of students' progress and achievement.	Tests or exams Prevalence of reproductive questions.	**Teacher as the key assessor.** Teacher's roles: Producing the tests; grading. Student: passive role.	Core concepts.	At the end of a unit.	Maintain the final score; review the content and redo some questions; re-teach; apply a new test. No feedback to students.	Other students	Career; product and discipline
	Teachers (T), Plans (P) and PPPs	**T = 9** T1, T3, T4, T5, T6, T7, T8, T9, T10	**T = 10** T1, T2, T3, T4, T5, T6, T7, T8, T9, T10	**T = 10** T1, T2, T3, T4, T5, T6, T7, T8, T9, T10	**T = 10** T1, T2, T3, T4, T5, T6, T7, T8, T9, T10	**T = 10** T1, T2, T3, T4, T5, T6, T7, T8, T9, T10	**T = 10** T1, T2, T3, T4, T5, T6, T7, T8, T9, T10	**T = 10** T1, T2, T3, T4, T5, T6, T7, T8, T9, T10	**PPP = 3** PPP1, PPP5, PPP9 **P = 2** P1, P9
	Assessment *FOR* Learning Formative	**Pedagogical** Creates descriptions that can be used to help in further learning; provide opportunity for student learning.	Variety of information sources (formal and non formal evaluation).	**Interaction between students and teachers.** Teacher's roles: provide feedback and support to each student; identifies particular learning needs. Student's roles: contributor to the assessment and learning process.	Core concepts and skills.	During the course of a unit of study.	Make adjustments and revisions to instructional practices.	External standards or expectations	Pedagogy; democracy and process
	Teachers (T), Plans (P) and PPPs	**T = 5** T1, T2, T4, T6, T7		**T = 0**			**T = 3** T1,T4,T9	**N = 0**	
Innovative	**Assessment *AS* Learning** Formative	**Pedagogical** Enhance learning;		**Student as the key assessor.** Student as the critical connector between assessment and learning process; metacognition: students personally monitor their learning and use the feedback to make adjustments, adaptations, and changes in what they understand.		Throughout the learning process.	Make adjustments and revisions to instructional practices. Continuous feedback.	Student's own prior work and targets for continued learning	
	Teachers (T), Plans (P) and PPPs	**T = 0**	**T = 7** T1, T2, T3, T4, T5, T7, T10	**T = 0**	**T = 0**	**T = 0**	**T = 0**	**T = 0**	**PPP = 5** PPP1, PPP2, PPP3, PPP5, PPP9 **P = 4** P1,P2,P5,P9

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Conclusions

The analysis revealed some contradictory relationships between teachers´ conceptions and beliefs and the current classroom assessment practices. This incongruence suggests that the current prevailing definition of accountability may be in conflict with the underlying beliefs and values reflected in the official educational documents.

The goals for chemistry teaching as declared by teachers during the interviews point to innovative designs and are in line with what is presented in the texts of the Brazilian official documents such as the PCN+. However, analysis of interviews with respect to the uses, methods and moments at which the assessment is carried out point to a fairly traditional design, which is consistent with the type of questions they use in the exams, mostly reproductive in nature. Thus, in general, both the schools and the investigated group of teachers, judging by the PPPs and the introductory part of the teaching plans, point to innovative designs. These innovative concepts are also present in the discourse of these teachers when they talk about the objectives of chemistry teaching or show that they want to be consistent with the official documents of current public policies. On the other hand, when we assess the actual practices of the classroom through the analysis of the pedagogical decisions made by the teachers as a result of the evaluations, the scenario is completely different, and very traditional conceptions emerge.

Assessment strategies for these investigated teachers are strongly correlated to transmission/assimilation or traditional teaching perceptions and are based on memorization skills and algorithmic and routine exercises. Results showed that students' roles within the assessment practice are highly underestimated. Teachers' roles with regard to assessment seem to be grounded in producing the exam questions and grading them. Students' roles are limited to answering the questions posed by the teachers. The questions are, for the most part, designed to evaluate students' lower-order thinking skills as opposed to their higher-order thinking skills.

The analysis also suggests that the main role played by the assessment processes can be described as certificatory and bureaucratic. As for the results of evaluations, if these results are not satisfactory, the analysis of teachers' attitudes suggests that students are held responsible for their poor performance, which can be improved through working on more exercises and offering new opportunities to improve the score by taking another test. Also, the results point to a technical plan that includes a methodological description of what is intended to be assessed and at which point in the learning process.

The current assessment model is characterized by a grading that is typically practiced at the end of the learning process; this assessment is predominantly for certification purposes, and the obtained grade is the most important evidence of learning. For this model, there is no feedback to the students about their learning stage because the learning process is not followed, and the final score is a partial summary of the notes, usually divided into small teaching units. The use of an average score is an indication that there is no monitoring of the development process of student learning, as well as to overcome students' difficulties. In a concept of teaching and learning in which assessments have a formative character and contribute to student learning, the grades obtained at the end of the process would be better than at the beginning, and thus, the use of average score would not be justified. Data analysis indicates that most teachers do not discuss the evaluation criteria with students. This attitude does not favor the students' understanding of how the assessment would be practiced and to which expectations and criteria they are expected to respond, making it difficult for the students to self-regulate their learning.

Therefore, the analyses of results show an inconsistency between the intentions and the implementation of actions in the classroom. Both the PPPs and the teaching plans expressed alternative concepts of teaching and learning; these concepts were also observed in the teachers' statements about the objectives of teaching chemistry in high school. However, analysis evidenced compiled by these teachers and the responses to interview questions that sought to reveal how the assessments are actually practiced are clearly related to a traditional conception of education, pointing to a transmission/assimilation educational practice. There is a significant difference between teachers' educational intentions and the reality of the classroom.

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The analyses in this study reaffirm the inseparability proposed in the Morine-Dershimer and Kent model (Figure 2). In this model is proposed that assessment procedures, evaluation of outcomes is inseparable from educational ends, goals, purposes and values and, affects the knowledge of curriculum and pedagogical knowledge and consequently, the PCK. The same conclusion can be reached if the Magnusson et al. model (Figure1) is used. The component "orientations for teaching science" in this model shapes the knowledge of assessment and directly influences teacher´s PCK.

Implications

A shift from summative upon formative assessment practices depends upon a high degree of interaction of some of the major PCK components. Teachers need to be able to use their knowledge of the students and their understanding of the goals for chemical education and curriculum in the context of the assessment. This represents a considerable challenge for most teachers. As a result of failing to coherently overlap these different knowledge domains, assessment practices often contrast with teachers' educational objectives.

The teaching-learning concepts that emerge from the analyses of the teachers' speeches and the guidelines outlined in the documents that define teachers' classroom practices (teaching plans and political pedagogical projects) are closely aligned with the educational directives suggested by the curricular restructuring, expressing student-centered teaching models and giving emphasis to the importance of students´ development and the learning process. The research reveals, however, that classroom actions are in contrast to such ideas, at least with respect to assessment procedures. The systematic analysis of the purposes and methodology of the evaluative process performed by the investigated teachers suggests a strong correlation to a content-based teaching practice, based on a transmission/assimilation model, where the main goal of the assessment practice is certification.

The research results suggest that comprehension with regard to the different roles that the evaluation process may assume does not spontaneously occur. An intervention through teachers' in-service programs (continuous professional development, CPD) is necessary, focusing on the correlation between teaching-learning conceptions, didactic models and the assessment of learning (Mamlok-Naaman; Rauch; Markic & Fernandez, 2013).

This study also revealed that assessment is an uncomfortable process because the certification involves notes and subjects teachers to social and political pressures causing them to develop defense strategies. Assessment practices have been used as a tool for the preservation of pedagogical authority, control and power over the discipline of students.

It was found during the research, the process of evaluation, while widespread, receives little reflection and is not well understood due to its complexity. We believe that the study of learning assessment in conjunction with curriculum and planning demands an extraordinary effort, but it is necessary because reflecting on these aspects means thinking about all the pedagogical actions in a coherent and useful way, allowing more concrete and effective actions, especially with respect to the actualization of the proposed curriculum reform.

This research reveals the lack of knowledge in the assessment field and strongly suggests the necessity to invest in continuous professional development programs, especially with respect to assessment practices. Thus, it is necessary for in-service courses for teachers with an emphasis on assessments of learning, the coherence between assessment practices associated with concepts of teaching and learning, also consistent with the educational projects and planning, especially in chemical education. This consistency will not be achieved spontaneously without understanding the inseparable relationship between curriculum and assessment; yet, without this change in assessment practice, no curriculum change is possible.

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