ACTA SCIENTIAE

ISSN: 2178-7727
DOI: 10.17648/acta.scientiae.v21iss1id3777

The Pedagogical Education of Chemistry Teachers: A Critical-Reflexive Analysis of Teacher Education

Lairton Tres[1], José Claudio Del Pino[2]

[1] Universidade de Passo Fundo, Instituto de Ciências Exatas e Geociências, Departamento de Química, Passo Fundo, RS, Brazil.
[2] Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Educação em Ciências, Porto Alegre, RS, Brazil.

Received for publication on 28 Dec. 2017. Accepted, after revision, on 3 Jun. 2018.

ABSTRACT

This article discusses the pedagogical aspects of the chemistry teachers training course of a community university in the state of Rio Grande do Sul. The course got through several curricular reformulations, which enabled the implementation of chemical education subjects, responsible for the articulation of technical and pedagogical knowledge throughout the course. We did a structured interview with the course's graduates and then made a critical-reflexive analysis of the developed work, trying to understand the former students' perspectives about the parameters used as indicators for their education and the contributions of this process towards the construction of chemistry teachers. Among the main results, we highlight the importance of the actions in chemical education established to allow the insertion of the future teachers in the school context from the beginning of the course. This encouraged them to become researchers of a reflexive practice and to establish themselves as mediating educators in the teaching-learning process, creating the link between technical and pedagogical knowledge by teaching.

Keywords: Critical-Reflexive Practice. Chemical Education. Teacher Education.

A Formação Pedagógica dos Professores de Química: uma análise crítico-reflexiva da formação docente

RESUMO

Este artigo retrata o trabalho pedagógico realizado na formação docente em Licenciatura em Química numa universidade comunitária do Rio Grande do Sul, desenvolvido após sucessivas reformulações curriculares que permitiram implementar disciplinas de Educação Química, responsáveis pela articulação dos saberes técnicos aos saberes pedagógicos ao longo da graduação. Por meio de entrevista estruturada, realizada com egressos do curso, foi possível fazer uma análise crítico-reflexiva do trabalho desenvolvido, buscando entender a percepção desses diante dos parâmetros que serviram de indicativos para a sua formação e as contribuições desse processo na constituição do docente em Química. Entre os principais resultados, destaca-se a importância das

Corresponding author: Lairton Tres. Email: lairton@upf.br

ações em Educação Química estabelecidas para permitir a inserção dos acadêmicos no contexto da escola desde o início da graduação, incentivando-os a serem pesquisadores de uma prática reflexiva e a constituir-se como educador mediador no processo de ensino-aprendizagem vinculando os saberes técnicos aos pedagógicos na realização da práxis docente.
Palavras-chave: Prática Crítico-Reflexiva. Educação Química. Formação Docente.

INITIAL CONSIDERATIONS

Brazilian higher education system has two types of undergraduate degrees: bachelor and licentiate. The degrees obtained in both are equivalent, but the bachelor course is directed towards a more technical education, while the *licenciatura* course is focused on teacher training. In present times, the apparent context for chemistry teacher education is linked to the idea of a reality-based education, as opposed to the traditional processes that developed in the Country through time, in which the technical and the pedagogical parts were completely separate. This was known as the 3+1 system, with three years of technical education and only one year of pedagogical education at the end of the course. This was done mainly to integrate the *licenciatura* and bachelor curricula.

In 2000, the Ministry of Education proposed new guidelines, aiming at, among other things, untying the *licenciatura* from the bachelor course. This allowed the establishment of a more effective teacher education, since the prior model had the teacher education as an attachment to the baccalaureate. The intention behind this model was for the bachelor to be able to "become a future researcher in that area of knowledge or work in different areas of the labor market and, as an added choice, have the possibility to become a teacher at primary or secondary schools" (Brasil, 2000, p.22). The main focus was not on the education of the teacher, but on the education of the bachelor.

Looking to adapt to the new reality, a community university (a private-run, non-profit institution) in the state of Rio Grande do Sul created a new chemistry *licenciatura* curriculum, not only because of the laws, but also because of the involvement of the professors in debates about chemistry education. Once the curricular reform took effect, in 2002, the chemistry education subjects, which were distributed since the very first semester throughout the course, started being offered. They functioned as "bridges" between the technical and pedagogical knowledge.

In 2008, another curricular reform took place and, among the advancements made, we highlight the integration between theory and practice in the course's technical subjects. With this, in addition to the chemical education subjects, *licenciatura* started to establish an articulation between theory and practice throughout the course, with theoretical and practical credits interspersed in the semester, making it so that the practice stopped being only the confirmation of the theory and started being articulated in the educational process. The debates between the professors of the University's Chemical Education Center allowed for the development of a differentiated posture regarding the teaching method and general education of the chemistry licentiates (Lauxen & Del Pino, 2016).

This article evaluated the effects of this specific education in the construction of the teacher identity. This was done through critical-reflexive analyses of structured

interviews of the students who graduated between 2006 and 2015. These are the students who were influenced by the changes made in the curriculum. We aimed at identifying the contributions and the advancements and/or setbacks that were established with the new curriculum and that work as basis for the chemistry teacher education.

THE CHOICE OF RESEARCH METHODOLOGY

We chose a mixed methodology for this research, which associates qualitative and quantitative methods, because the combination of these types of data might enrich the understanding of facts, facilitating comprehension and allowing a more accurate critical analysis (Gatti, 2004).

Regarding quantitative analysis, the use of Liker-type scales (Likert, 1932) is indicated as important for the investigation and research processes. Such scales allow us to judge values through the graduated answers and to verify the group's consensus in relation to them (Tastle & Wierman, 2007). Thus, we chose a closed Likert-style questionnaire (Likert, 1932) for our research because it provides for an efficient evaluation of consensus and agreement degrees to the proposed situations. Vian and Del Pino (2015) highlight that the results compilation can be presented as a graphic, showing the sum of the corresponding scores. To each of the alternatives (completely agree, agree, undecided, disagree, completely disagree) we assigned weights (5, 4, 3, 2, 1, respectively) so that, with the data obtained to each alternative, it was possible to calculate the score of each assertion. The score is the percentage of the response in each alternative multiplied by the respective weight. The question's total score is obtained by summing the score of the alternatives and is calculated from Tastle and Wierman's (2007) proposition, by using

the following equation: $\mu X = \sum_{i=1}^{n} pi\ Xi$ in which, μX means the score; $\sum_{i=1}^{n}$ means the summation; *pi* means probability or frequency is equal to $\frac{n^{\circ}\ of\ answers}{total\ n^{\circ}\ of\ answers}$; *Xi* alternative weight ranging from one to five. With the data obtained from each alternative, we calculated the score of the statement.

We analyzed questions 5 to 26 by calculating the percentage of responses and the scores of each question. The total responses to each alternative were given in percentage in relation to the total answers of each question.

For the analysis of the results, we adopted the following criterion: from 1 to 2, full disagreement; 2 to 3, disagreement; 3 to 4, agreement; 4 to 5, full agreement. Considering this scale of one to five, the scores that provide values equal to or greater than four are considered high and show evidence of partial or total agreement with the presented situation. On the other hand, values lower than three are considered low and relate to partial or total disagreement to the affirmative. This allowed us to draw a profile of the responses, expressing the consensus of the interviewees' opinions on the statements presented (Vian & Del Pino, 2015).

In the quantitative analysis, after obtaining the scores and presenting the results in graphics, the qualitative interpretation of the data is necessary for the critical analysis

of the information found and the understanding of what determines the established consensuses (Gil, 1999).

DATA COLLECTION: INTERVIEW WITH THE GRADUATES

We designed a questionnaire (Gil, 1999), that was answered by the graduates of the chemistry *licenciatura* course, in order to understand and evaluate the teacher education process established in the focused institution and the relation between this process and the chemical education subjects added to the curriculum. In this questionnaire, we explored the characteristics related to the profile of the interviewees and to the situations involved in their experiences being educated as a chemistry teacher.

We used documents from the course (the course's Pedagogical Project (PPC), from 2002 and from 2008, and its historic) and documents related to the guidelines for the teaching of chemistry (National Curricular Parameters (PCN) and National High School Curriculum Guidelines (DCNEM)) as a basis for our questionnaire.[1] It contains sixty closed questions about teacher and chemical education.

Parallel to this, we contacted the chemistry course secretary in order to gather the graduates' addresses and to find out which of them were working or had worked as teachers. We found a total of 107 people who graduated between 2006 and 2015, chosen because they studied under the new curriculum, and of those, 77 were or had been teachers[2] and were, therefore, selected as our investigation's sample.

We elaborated the questionnaire in a closed-question style, with statements that could be answered through the Likert scale, with the interviewees evaluating their degree of agreement or disagreement to the sentences. It had 26 objective questions aimed at evaluating the educational process and what chemical education represented in their education as chemistry teachers.

The questionnaire's validation, the pretest (Gil, 1999), was done with the professors of UFRGS' Science Education: Chemistry of Life and Health postgraduation program (PPG), of UPF's Education PPG and Science and Mathematics Education PPG, and with the UPF's chemistry *licenciatura* course coordinator. They made some suggestions and indicated some wordings that could be misinterpreted. We used *Google Forms*® to facilitate the posterior organization and compilation of data. We opted for applying an electronic questionnaire to facilitate the interviewees' access and to obtain a significant return.

We searched for the graduates through *Facebook*®, which allowed us to locate most of them, and sent the link to the questionnaire through it as well. Those that we did not find this way, we called, asking for their emails in order to send them the link.

[1] Article published in the RBPEC Journal. (Tres & Del Pino, 2017).
[2] This clipping was necessary because we understand that it is the act of teaching that makes a teacher.

The questionnaire's statements were made to be evaluated following the Likert scale. The possible answers were: (5) completely agree, (4) agree, (3) undecided, (2) disagree, (1) completely disagree, and their respective values for the scores' calculation were five, four, three, two and one.

The questionnaire was applied on the second half of 2015. Before answering the questionnaire, the interviewees had to agree or disagree with the Informed Consent Term (TCLE). We sent the questionnaire to 70 graduates, receiving a return from 45, one of those declined the consent form, which left us with 44 total responses.

RESULT ANALYSIS AND INTERPRETATION

We started the analysis by evaluating the 26 questions, the first 4 being multiple choice and the other 22 also being multiple choice, but in the Likert-style. We calculated the score for each of the Likert-style questions and generated the graphics for each of them. Afterwards, the questions were divided in blocks according to their themes, consolidating new categorizations, always following the theoretical references and the critical-reflexive approach to the investigation.

The table 1 shows the questionnaire we applied:

Table 1
Questions of the structured interview applied to the graduates.

Questions related to the interviewee's profile:
1- What are your academic qualifications?
2- Professional teaching experience:
3- Total time of teaching experience:
4- Educational stages experience:
For the following questions, analyze the sentence and signal your degree of agreement, being (5) completely agree, (4) agree, (3) undecided, (2) disagree and (1) completely disagree.
The next four questions aim at finding if your chemistry graduation course:
5- Articulated, when possible, the relation between theory and practice in the subjects.
6- Encouraged the development of experimental activities in the science/chemistry teaching-learning process in an investigative and problematizing way.
7- Gave precedence to the technical knowledge over practical-pedagogical knowledge.
8- Encouraged the use of different methodologies that articulated theory and practice for the construction of chemical knowledge.
The proposals brought by the chemical education subjects provided you with the opportunities to:
9- Be inserted in the school context from the start of the course, which allowed you to build yourself into an educator, by incentivizing you towards a reflexive practice research.
10- Articulate the pedagogical theory and practice, during the course, through the chemical education subject.
11- Study Brazilian legislation, such as LDB, PCN and DCNEM, and educational theories during the course, aiding in building you as a professional and in the understanding of the chemical education process.

The proposals brought by the chemical education subjects provided you with the opportunities to:
12- Develop the practical rationality, in opposition to the technical rationality, breaking with the conception of a disciplinary, divided and reductionist education.
13- Through a research-based education, rupture with the reproduction/transmission model, instead teaching through a critical-reflexive perspective.
14- Teaching methodologies based on reproduction and transmission to prevail in the teaching-learning process with expository classes guided by the textbook adopted by the school.
15- Have contact with the work environment, the school, parallel to the graduation, so that the analysis of the practice of the experienced teacher allows the construction of the professional identity.
From what you experienced in your graduation, it is possible to affirm that:
16- Due to factors such as the lack of infrastructure, the difficulty of access to adequate materials and the lack of collaboration from colleagues in the area, it becomes difficult to put the proposals of the chemical education subjects into practice, in the school.
17- Teachers of chemistry/science who had a more technical-pedagogical training are better prepared to perform classroom work.
18- The construction of concepts developed from the debate and interaction in the micro-classes, in the perspective of didactic transposition, was important for the critical analysis of reality and preparation to act in the school.
19- It is necessary to establish oneself as a mediating educator in the teaching-learning process by developing teaching based on the students' experience from problem situations, aiming at the continuous construction of knowledge.
20- The chemical education and other pedagogical-focused subjects failed to break with the idea of technical rationality often present in other subjects of the course, making it impossible to prepare for critical-reflexive teaching.
21- The chemistry course showed the construction of knowledge that might produce interactions and transformations in the process of teaching and learning in the field of chemistry, enabling reflection on the action.
22- The initial training offered at universities should contribute to the formation of a teacher capable of interfering creatively in the complex situations of the school through reflection on one's own experience from the beginning of formation.
23- UPF's chemistry *licenciatura* course contributed towards the building of a professional committed to the issues related to chemical/science education.
24- The evaluation methods in the chemical education subjects, such as text elaboration, didactic books analysis, involvements with researches in the school and the micro-classes, qualified the teaching and learning process.
25- The course allowed you to see yourself as a teacher and researcher of your practice, able to reflect on your actions.
26- The inclusion of discussions about pedagogy since the beginning of the course makes it difficult to consolidate the course's chemical knowledge.

The results from the first block of questions, from 1 to 4, gave us the profile of the interviewees, with the following results:

Regarding academic qualifications, in question 1, the results were: 50% have only the chemistry *licenciatura* degree and the other 50% have some type of postgraduate degree, finished or ongoing, in chemistry, education or chemical/science education. Regarding their professional teaching experience, in question 2, we highlight the predominance of State schools, with some of the interviewees sharing their time with the municipal or

private schools, totaling 86.4% and only 13.6% teaching only in municipal or private schools. Regarding the total time of teaching experience, in question 3, the answers were: 38.7% answered from one to three years, 31.8% from three to five, 22.7% from five to eight, 4.5% from eight to ten and 2.3% answered more than ten years.

Regarding the answers to the educational stages in which they taught, in question 4: 88.7% of the interviewees taught secondary school chemistry, 63.7% taught science in the final years of primary school, and 13.6% taught some chemistry subject in higher education. To understand these results, one must understand that some of the interviewees teach in more than one stage of the educational system. Therefore, we emphasize that these data should be read in relation to the total of graduates, not in relation to the other groups. These results show that most graduates were able to find work in their area of graduation.

The results compilation is presented as a graph (figure 1) that shows the sum of the scores corresponding to the presented alternatives. In the graph, the X-axis represents the questions (Q) with their corresponding numbers, and the Y-axis shows the values of their scores, with the values on top of each bar.

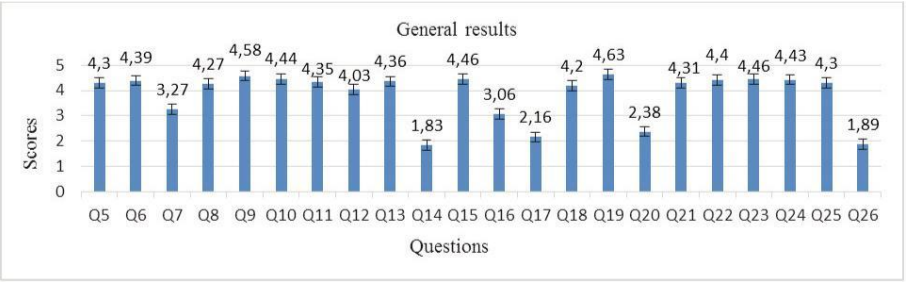

Figure 1. General results obtained for the Likert-scale questions.

The generated graph shows the quantitative result of the research and, in a general analysis of the scores, we see that the interviewees completely agreed with most of the statements (i.e. questions 5, 6, 8, 9, 10, 11, 12, 13, 15, 18, 19, 21, 22, 23, 24 and 25). The scores for questions 7 and 16 show the interviewees agreed with the statements. Questions 17 and 20 show scores that indicate disagreement, while questions 14 and 26 indicate complete disagreement.

Our analysis is that the interviewees:

I - *Completely agree* with the statements in the questions 5, 6, 8, 9, 10, 11, 12, 13, 15, 18, 19, 21, 22, 23, 24 and 25, that are about the chemistry *licenciatura* course, recognizing that the course sought: to establish actions that articulate theory and practice, with experimental investigative and problematizing activities and differentiated methodologies for the construction of chemical knowledge; to insert the students in the school context as researchers of a reflexive practice; to promote the articulation between theory and

pedagogical practice through the chemical education subjects; to study the legal documents and educational theories for the understanding of the chemical education process and the development of practical rationality in opposition to the technical rationality; to establish a critical-reflexive conception through the education through research; to promote contact with the school for the construction of the professional identity and to prepare for working in the classroom through micro-classes, highlighting the role of the teacher as mediator in the teaching-learning process; to evidence in the process of teaching reflection in and about the action, reflecting on the experience itself from the beginning of the course; to promote differentiated assessments to qualify teaching and learning.

II - *Agree* with the questions 7 and 16 pointing towards some possible problems: the curriculum gave more attention to technical knowledge over practical-pedagogical knowledge, which shows that the technical education still took precedence in the curriculum; and the fact that the proposals debated in the chemical education subjects might be affected by several factors when being applied in the schools, such as lack of infrastructure and collaboration with colleagues of the area, aspect that justifies keeping the traditional position.

III - *Disagree* with the facts presented in the questions 17 and 20, which shows that the graduates believe that: a more technical-focused education does not better prepare a teacher for classroom work; and that the chemical education and other pedagogical subjects can break with the technical rationality, preparing for critical-reflexive teaching.

IV - *Completely disagree* with questions 14 and 26, showing that the interviewees believe that: traditional methodologies, based on reproduction and transmission of content should not prevail in the teaching-learning process; and that having pedagogical discussions since the beginning of the course helps with the consolidation of chemical knowledge through the academic education.

After the general analysis, we focused on interpreting the results by dividing them into three blocks according to the statements. They are: (a) what the educational process during the chemistry course allowed; (b) what the proposals established by the chemical education subjects offered; and (c) what the graduates can say from what they experienced during the course.

The graph (figure 2) and results interpretation for the (a) block are:

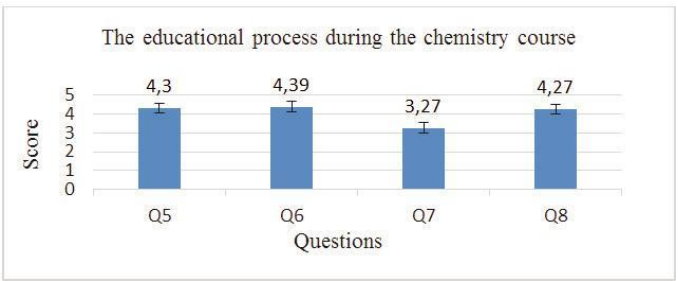

Figure 2. Results related to the educational process.

It is noticeable, by the interviewees' agreement with questions 5, 6 and 8, that the educational process sought to break with traditional teaching methods, based on the reproduction of theories throughout their teacher education, through the articulation between theory and practice, development of experimental investigative and problematizing activities, and differentiated methodologies.

For Echeverría and Soares (2007), the initial teacher education is the essential part for the constitution of the teacher, that is, for what they will later become as professionals, and they corroborate that "[...] the initial education offered in universities needs to be rethought and redirected in order to contribute to the formation of a teacher who can creatively interfere in complex school situations" (p.181).

This criticism towards the initial education refers to the fact that the education model received will work as support for the actions of the future teacher. Thus, this model must involve the individuals in dynamics that allow the construction of knowledge and not only its reproduction. Echeverría and Soares (2007) emphasize the contributions of Carvalho, Gil-Pérez, Sacristán and Perez Gomes, who believe that non-reflexive education and decontextualized teaching is a difficult rupture to be made by the teacher who was educated in a passive way, whose tendency will be to follow the model to which they were submitted. Therefore, the reflexive education, in which the articulation of the technical knowledge with the pedagogic knowledge occurs, is necessary. In a way, this rupture is being made in the course, because, in the evaluation of the graduates, they can perceive the differential of their education.

It is known that, although the *licenciatura* courses are often articulated to the chemistry bachelor courses, sharing the basic subjects, as is the case in the investigated institution, there is a need for the training teachers to develop differentiated, problematizing methodologies, that promote debates related to the pedagogical field during the teaching of content.

The result of the score of question 7 showed the indecision of the graduates in relation to the idea that their education "privileged the technical knowledge over the pedagogic one". In this sense, although advances in the educational process of the course lead to a contrary view, many of the graduates still perceive technical knowledge as predominant, perhaps, due to the subjects of basic and specific chemical knowledge that end up assuming the character of technical education because they constitute the "hard core" of the course.

Facing the problem highlighted in question 7, there is a concern about what would be "good teaching" for the education of future chemistry teachers. According to Garritz (2012), "the formation of individuals is necessary in an integral and uninterrupted manner in three broad areas: the set of knowledges (knowledge), skills (knowing how to think, knowing how to do) and attitudes (knowing how to be and live with others)" (p.129). Thus, it is evident that "[...] a good teacher can achieve the goal of scientific education, that is, the development of autonomous individuals who resort to scientific reasoning as a norm, who [...] assume the ethical responsibility of their actions" (Garritz, 2012, p.129).

It becomes necessary for the teacher educator to go beyond the commitment to technical knowledge to be established in the teaching process. It is necessary to go to the humanities, seeking a balance between human and scientific aspects, in order not to become excessively humanistic or too scientific (Garritz, 2012).

For Zabalza (2007), the teacher educator needs to perceive himself as a 'teacher' in his area and be able to break with the excessively technical teaching, seeking the interrelation between technical and pedagogical knowledge for the education of individuals, so that they can see themselves as educators. In the teaching-learning process, it is important for students to "[...] learn, in an implicit and not over-reflected-about way, the ways of acting in the classroom. This requires a constant questioning of what one is, as a teacher" (Galiazzi, 2003, p.175). In this way, one needs to break with the "purely technical and 'objective' aspects that prevailed during almost all of the past century" (Imbernón, 2016, p.52). To do this, "we must look for new solutions to new problems. It is necessary to deconstruct much of the knowledge about teaching" (Imbernón, 2016, p.22).

For block (b), here follows the graph (figure 3) and the interpretation of the results:

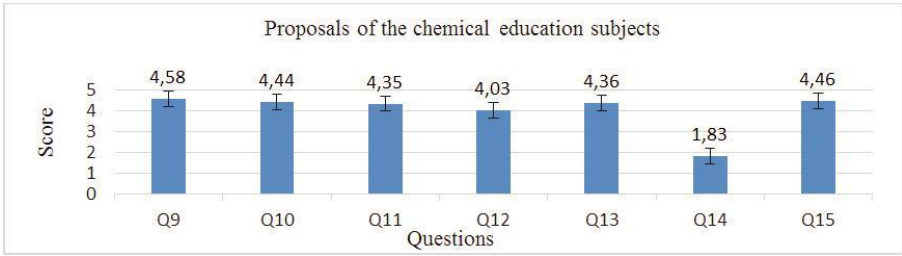

Figure 3. Results related to the proposals of the chemical education subjects.

The statements that are part of block (b) related to what the proposals that were established by the chemical education subjects offered, considering that during the course, six subjects worked on aspects related to chemical and practical-pedagogical education of the future teacher: introduction to chemical education, chemical education I, II, III, IV and V. They were developed in one semester each, in the first three years of the course, before the internships, which take place in the two final semesters.

The interviewees agreed with most of the questions proposed in this block. Looking at the questions 9, 10, 11, 12, 13 and 15, we highlight the significance of the actions developed through the chemical education subjects through the course. These subjects enable a dialectical process of reflection and action, in which theories and practices were kept in constant interaction, contributing to a practical rationality, as opposed to technical rationality, strengthening the education through research.

In relation to the role of chemical education in the "articulation between theory and practice" in the teacher education, Perrenoud, Thurler, Macedo, Machado and

Allessandrini (2002) consider the need for a true articulation between theory and practice, different from an outlook that allows only moments of practice, but that expresses a constant relationship between the two. In the subjects of chemical education, this view is clear, according to interviewees' answers, due to the fact that practical-pedagogical issues are addressed in this bias. This is reaffirmed by analyzing the disagreement with the idea that reproduction and transmission should prevail in the teaching-learning process. "It is necessary to combat this dichotomy and affirm that education is one, theoretical and practical at the same time, as well as reflexive, critical [...] and that all educators: feel equally responsible for the theory-practice articulation and work for it [...]" (Perrenoud et al., 2002, p.23).

In the perspective of "educating through research", it is understood that through this it is possible to develop critical-reflexive teaching and also the involvement with the world of the school parallel to the course, because, in this research space, the school is perceived as a research area. With this, the undergraduate classroom presents a permanent challenge: to enable future teachers to understand the principles of "what it is to be" and what the role of "being a teacher" is.

Demo (2015), when analyzing "education through research", demonstrates the epistemological sense of this practice, which would be a way of teaching in which teacher and student become subjects of the process, not being reduced to objects of transmission and receiving, but being recognized as constructors of knowledge, given the dynamics involved. Through the research, is found the emancipatory sense of the person that is constituted by the systematic questioning of reality where practice is necessary to develop the theory, encompassing the ethics of ends and values. "The characteristic of emancipatory education demands research as its formative method, mainly because only an environment of individuals generates individuals" (Demo, 2015, p.10). This aims to break with the traditional teaching methods, either based on transmission and reception or that fall back on the "banking education" (Freire, 2003), commonly developed among the individuals in their educational process.

Therefore, the challenge proposed for the teacher education is the education not of individuals who only instruct and transmit knowledge. Rather, as someone who can go beyond mere transmission, who has "reconstructive questioning, fed by research as a scientific and educational principle" (Demo, 2015, p.12) as a brand, who is capable of "assisting in research with guiding instructions, as a tactic of reordering the work, or with sporadic interventions" (Demo, 2015, p.12). Higher education, by allowing critical-reflexive teaching, makes it possible to understand the future reality of teaching, which means that "the university could prove to have an essential and generative role in the face of human development [...] having as crucial instrumental lever the innovative knowledge" (Demo, 2015, p.67).

It is clear that educating through research presents itself as an important commitment to be faced in the education of future teachers. Galiazzi (2003) emphasizes that "education through research can be a possibility for the integration of the curriculum by research,

contributing to minimize the problem of *licenciaturas*, [...] which is the separation between content and pedagogical subjects" (p.266). Research as a didactic principle favors the approximation between teaching and research in undergraduate education and can, "[...] since the first semesters of the undergraduate course, contribute to a more integrated curriculum" (Galiazzi, 2003, p.266).

Question 14 was the only one in this block, according to the scores' calculations, in which most of the interviewees showed disagreement. Said question was by design contrary to what a priori is thought about the established educational process. That makes it evident that methodologies based on reproduction and transmission should not prevail in the teaching-learning process, mainly due to the fact that in the chemical education subjects the use of differentiated methods was encouraged, favoring the construction of scientific knowledge. The question, however, stated the opposite, to make this purpose clear in the investigation and corroborate with new proposal of curricular organization, including these subjects, over the semesters, to make the necessary "bridge" between scientific and pedagogical practical knowledge. This is fully corroborated by the interviewees' full agreement to the other questions of this block.

In the interpretation of this block's answers, we highlight the need for "academia-school articulation", in the construction of the teacher as researcher of a reflexive practice since the educational process. "The teacher, during under- or postgraduation, must understand their own process of school knowledge construction and production, and understand the differences and similarities of the process of scientific and school knowledge production [...]" (Diniz-Pereira, 2006, p.47).

However, several factors prevail in universities, encouraging the idea of a lesser value for the *licenciaturas*, as opposed to the more technical courses, implying that there is no research in the *licenciaturas*. This ends up reinforcing the devaluation of the teachers even inside the academy, and this prejudice spills over to the schools and the students (Diniz-Pereira, 2006). This is an aspect that should be faced by the higher education institutions, by taking a position of appreciation of the *licenciaturas* as an essential factor for their own survival and for maintaining teaching, researching and extension, the three pillars of higher education.

In the analysis of the questions about the chemical education subjects and what they enabled, we see that the interviewees believe "the study of documents and educational theories" to be necessary for the understanding of the chemical education process. Looking at these subjects, we see programs with this objective.

Regarding "practical rationality as opposed to technical rationality", most of the interviewees agree it is needed in order to break with the disciplinary, divided and reductionist education. Since the technical solutions for problem solving can only occupy a limited space, they make for a radically incomplete model (Schön, 2000). With the practical rationality, the reflexive action is established, in which the practice comes close to the research.

The chemical education's proposals gave the students the opportunity to reflect about practice and fueled debates regarding the conflict between technical and practical rationality in order to promote autonomy (Freire, 2003) during the course.

We go on to the block (c), showing here the graph (figure 4) followed by its interpretation:

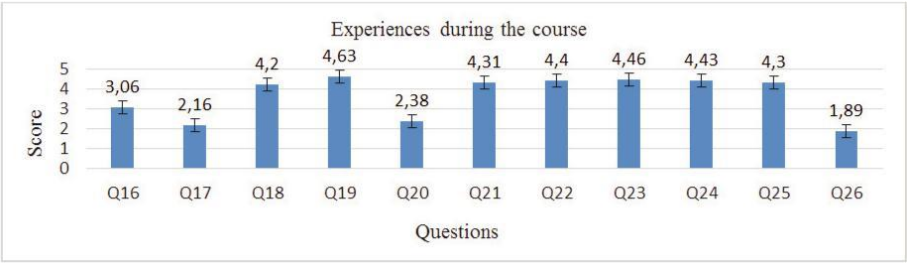

Figure 4. Results related to the experiences during the course.

The scores reveal, in this block, an agreement with aspects that involve the educational process established by the chemical education subjects. We highlight that its proposal is challenging and different from the traditional molds, that have the teacher as mediator of the process of teaching-learning capable of assisting in the construction of knowledge, with initial training having an important contribution to reflective practice.

Although question 16's score comes close to neutrality, we can see some agreement with the statement. In it, some impediments to the implementation on the classroom of the actions developed in the chemical education subjects is shown, such as: lack of infrastructure, adequate didactic materials and collaboration of the colleagues. Despite this, the fact that the different alternatives proposed during the course are not put into practice can be a pretext to justify the traditional practices that prevail and are maintained in many schools, based on the transmission/reception. Thus, "the context of mere training, marked by passive and imitative reception, is not overcome. This has nothing to do with the challenges of innovation, which imply reconstructed knowledge and alternative capacity for intervention" (Demo, 2015, p.20). In contrast, it is necessary to understand that the teacher, when guiding a joint, collective or individual work, does not lose his authority, but becomes a work partner allowing school education to be done and re-done in and by research (Demo, 2015).

Questions 17 and 20 got scores between 2 and 3, which show disagreement. These questions intentionally presented ideas contrary to the conceptions established in the educational process. In them, we pointed to some ideas, such as the technical character of teaching being fundamental in the preparation of teachers and the fact that in the educational process there was no break with the technical rationality established in the course. The answers of the graduates show that the course did break with the idea of technical rationality, making it clear that the mastery of the technique is not enough. The teacher needs to understand how the specific chemical knowledge can make sense to the

students. Question 26, which also brought an idea contrary to what is believed to be ideal for teacher education, had a score under 2, meaning complete disagreement. This question brought up the difficulty of developing pedagogical discussions since the beginning of the course and it was the item with the lowest score. This allows us to ascertain that having discussions related to chemical education from the very start of the course is a favorable aspect to the education of the chemistry teacher.

Questions 18, 19, 21, 22, 23, 24 and 25 all got scores between 4 and 5, which means complete agreement. We grouped the relevant information contained in these questions.

Questions 18 and 19 show that the micro-classes were fundamental for the education of the teachers. They work as a methodology to observe the process of didactic transposition to be established for the construction of concepts and the need to teachers to establish themselves as mediating educators in the process of teaching-learning, working problem situations that start from the experience with the continuous construction of knowledge. Question 19, the one with the highest score in this block, highlights the importance of the teacher's role as the mediator for the construction of knowledge. Maldaner (2013) points out the influences that teacher education can manifest in the future actions of the new teachers: one of them is based on the *reproduction* of teaching models that they had in their own learning experiences, in a tacit, non-reflexive way and teacher domination throughout the class situation; and another, based on *imitation* that, unlike reproduction, is a process of professional competences and intellectual development, involving a reflection in the action (Schön) and the reconstruction of what the individual sees in others, in an interpersonal process, creating zones of development (Vygotsky) so that "the teacher in training internalizes the process and reconstitutes for himself, becoming a teacher. This is possible in dialogic processes in which teachers and students are concerned with the knowledge conveyed" (Maldaner, 2013, p.390).

When the micro-classes are elaborated, presented and analyzed, in a dialogical process, the future teachers make use of a methodology that favors imitation rather than reproduction. Since the professor is the mediator of this process, the future teachers can reflect on and about the action developed, can think about the mechanisms necessary for the didactic transposition which induct the appropriation and (re)elaboration of the concepts, and can begin to understand how important mediation is for the facilitation of the teaching-learning process. Thus, "classical didactic approaches, focused on the classroom and on the performance of the teacher, have to give way to teaching methods centered on activities to be carried out by the students in autonomous ways" (Pimenta & Almeida, 2011, p.28). By starting from problem situations, based on the students' experiences, the teacher will be motivating and further enhancing the epistemological curiosity, fundamental for the construction of knowledge.

The graduates also showed complete agreement with the statements on questions 21, 22 and 23, from which we highlight that the chemical education course put in evidence: the construction of knowledge in the process of teaching and learning, allowing reflection on action; the initial education on the university, encouraging the reflection on

the experience in the school from the beginning of the course; and also allowing them to become professionals committed to issues related to education in chemistry/sciences. According to the above, it is necessary to educate the teachers/researchers in the process of interaction between the initial courses and the schools, constituting a critical mass that allows the continuity and expansion of the process developed" (Maldaner, 2013, p.392). Thus, when establishing the reflection on action, an epistemological rupture occurs, which breaks with ideas held as absolute truths found ready in nature, and moves towards the problematization of what is chemical science (Maldaner, 2013).

The graduates also showed complete agreement to questions 24 and 25, which emphasized that the evaluation styles in the chemical education subjects, with text elaboration, analysis of didactic books, involvement with researches in the school and micro-classes, made the teaching and learning process better; and the process of education allowed them to see themselves as teacher researchers of their practice, able to reflect on and in their actions. Understanding the evaluations as a part of the education of future teachers is essential because they establish those teachers' future evaluative practices. For Perrenoud et al. (2002), competences cannot be constructed without evaluation. Evaluations must not, however, follow the traditional tests-application-only, but should, rather, to be made into a formative process of learning regulation. The interview's results corroborate that the alternative evaluating practices of the chemical education subjects made the teaching-learning process better.

In order to think about the teacher education involving the idea of the teacher as a researcher of their practice, in a reflexive exercise in and on their actions, the relation established with the practice is fundamental. Nóvoa (1997) points out that there is a need for new approaches in the debate about teacher education in which they are shifted from the perspective that is excessively focused on the academic dimensions (areas, curricula, subjects) to a professional-centered perspective, essential to developing the autonomous and reflexive character of the future teacher. This education, in the perspective of the reflexive critic of reality, assists in the construction of the autonomous and professional identity, which cannot be given by the accumulation of knowledge and techniques, but by the relation with the environment where the practice is developed, in a work of critical reflexivity, in a permanent (re)construction through experience.

Scientific pedagogy overvalues science, legitimizing instrumental rationality and prioritizing scientific knowledge. Teacher education should, instead, be composed of a mix of models and practices that allow critical reflection about pedagogical work, keeping the balance between scientific and pedagogic knowledge (Nóvoa, 1997).

FINAL CONSIDERATIONS

The changes that the education of chemistry professionals went through since the disengagement of the bachelor and *licenciatura* courses demonstrate the professors' commitment with the education of chemistry teachers. The new teachers will be the ones to spread chemical knowledge in the society, in a reflexive relation. Over time,

the transformations that took place required (re)adaptations and successive curricular reformulations in order to enable the implementation of the principals of chemical education and teacher education.

In this research, by making use of both methodologies, we were able to make quantitative and qualitative analyses of the graduates' answers. We highlight not only the large number of answers we got, but also the finding that most of them are acting in the areas to which the course prepared them to, i.e. the teaching of science and chemistry. The Likert scale easily showed the agreement or disagreement with each sentence, making the qualitative analysis easier.

Even with all the effort put into the development of a course focused on the education of teachers, the *educational process during the course* still puts technical knowledge in front of practical-pedagogical knowledge. This shows that the idea that a good education should be based mainly on the acquisition of technical knowledge is still predominant. There was, however, a favorable emphasis on the articulation between theory and practice done in the subjects, using investigative and problematizing experimental activities and different methodologies.

In view of the established course, it becomes clear that the *proposals of chemical education allowed* the articulation of pedagogical theory and practice, which, in turn, allowed the development of practical rationality, as opposed to technical rationality, being the experience in school the main point for this process. It was through these subjects that the traditionally established dichotomy between technical and practical knowledge was overcome, when the future teachers had the opportunity to become reflexive practice researchers once inside the schools. The challenge is for these practices to go beyond the chemical education subjects.

Based on the findings of *what it is possible to affirm from what they experienced during their education*, it became clear that the graduates believe that the technical formation is not the main factor that prepares the teacher to act in the classroom, and, instead, that the role of the teacher as mediator of the teaching-learning process is more important. This way of thinking should be the main paradigm of the new teaching education university courses, aiming to give autonomy to teachers and students. Knowledge transmission should be overcome by knowledge interaction, as a part of the educational process, moved by research, with the teacher as a knowledge articulator and problematizer, allowing the students to build knowledge.

The results show how important it is to develop didactic-pedagogical actions from the very beginning of the course. It is not about presenting pedagogy or didactics by themselves, but about debating about the necessary didactic-pedagogic actions for developing the chemical and scientific knowledge. It is about finding the best way of working in favor of the scientific education process, which does not hinder the consolidation of chemical knowledge during academic education. The chemical education subjects broke with the idea of technical rationality, which is very present in other subjects of the course. The chemical education subjects prepared the students for a critical-reflexive teaching, establishing the reflection in and about teaching since the beginning of the course

and making it possible for the students to become teaching researchers in their field. For this to become a reality, there must be a way to build essential professional skills. The *licenciaturas* must focus on the school reality, with the professors of different teaching levels working in an integrated and reflexive way with the students, who will soon take the position of teachers.

Among the main results, we highlight that the chemical education process allowed the students to experience the scholar context since the beginning of the course, encouraging them to become researchers of the reflexive practice and to build themselves as mediating educators in the teaching-learning process, linking technical and pedagogical knowledges in their praxis.

It is important to consider that the challenges of teacher education are involved in a established confrontation between the mechanisms of control systems, generated intentionally by established educational policies, and the intentions and practices of a teaching process focused on the transformation of people and reality. Making the right choice falls on the institutions and on the professors.

REFERENCES

Brasil. (2000). *Proposta de diretrizes para a formação inicial de professores da educação básica, em cursos de nível superior.* MEC.

Demo, P. (2015). *Educar pela pesquisa.* 10.ed. Campinas, SP: Autores Associados.

Diniz-Pereira, J. E. (2006). *Formação de professores: pesquisas, representações e poder.* 2.ed. Belo Horizonte: Autêntica.

Echeverría, A. R. & Soares, M. H. F. B. Um núcleo de pesquisa em ensino de ciências (NUPEC) e a mudança nos parâmetros da formação inicial e continuada dos professores. In: Zanon, L. B. & Maldaner, O. A. (Org.). (2007). *Fundamentos e propostas de ensino de química para a educação básica no Brasil.* Ijuí: Ed. Unijuí.

Freire, P. (2003). *Pedagogia da autonomia: saberes necessários à prática educativa.* 28.ed. São Paulo: Paz e Terra. (Coleção Leitura).

Galiazzi, M. C. (2003). *Educar pela pesquisa: ambiente de formação de professores de ciências.* Ijuí: Ed. Unjuí.

Garritz, A. (2012). De químico teórico a professor humanista: uma vida afortunada. In: Carvalho, A. M. P.; Cachapuz, A. F.; Gil-Pérez, D. (Org.) *O ensino das ciências como compromisso científico e social: os caminhos que percorremos.* São Paulo: Cortez.

Gatti, B. A. (2004). Estudos quantitativos em educação. *Educação e Pesquisa*, São Paulo, *30*(1), 11-30, jan./abr.

Gil, A. C. (1999). *Métodos e técnicas de pesquisa social.* 5.ed. São Paulo: Atlas.

Imbernón, F. (2016). *Qualidade do ensino e formação do professorado: uma mudança necessária.* São Paulo: Cortez.

Lauxen, A. A. & Del Pino, J. C. (2016). O professor-formador e a sua constituição na dimensão reflexiva: existência de espaços/tempos de formação em serviço. *Atos de Pesquisa em Educação*, Blumenau, 11(3), 737-754 set./dez.

Likert, R. (1932). *A Technique for the measurement of attitudes – Archives of Psychology.* New York: n.140. p.1-55.
Maldaner, O. A. (2013). *A formação inicial e continuada de professores de química: professores/pesquisadores.* 4.ed. Ijuí: Ed. Unijuí.
Nóvoa, A. Formação de professores e profissão docente. In: _____. (Coord.) (1997). *Os professores e sua formação.* 2.ed. Lisboa: Publicações Dom Quixote. p.15-33
Perrenoud, P., Thurler, M. G., Macedo, L., Machado, N. J., & Allessandrini, C. D. (2002). *As competências para ensinar no século XXI: a formação dos professores e o desafio da avaliação.* Porto Alegre: Artmed Editora.
Pimenta, S. G. & Almeida, M. I. (Org.). (2011). *Pedagogia universitária: caminhos para a formação de professores.* São Paulo: Cortez.
Schön, D. A. (2000). *Educando o profissional reflexivo: um novo design para o ensino e a aprendizagem.* Porto Alegre: Artmed.
Tastle, W. & Wierman, M. (2007). Consensus and dissention: A measure of ordinal dispersion. *Internat. J. Approx. Reason.*, 45, 531-545.
Tres, L. & Del Pino, J. C. (2017). Pressupostos Político-Pedagógicos para a Formação Docente em Química. *Revista Brasileira de Pesquisa em Educação em Ciências. 17(3), 773–802.*
Vian, V. & Del Pino, J. C. (2015). Formação docente e a pesquisa no contexto do ensino politécnico. *Revista Didática Sistêmica*, *17*(2), 17-30.
Zabalza, M. A. (2007). *O ensino universitário: seu cenário e seus protagonistas.* São Paulo: Artmed.