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ARTIGO

A STUDY ON COURSES IN NATURAL SCIENCES IN BRAZIL

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ABSTRACT: In this article, we discuss the academic training of science teachers intending to work in middle school. We believe that the teacher who teaches at this level should have an exclusive training, as students from the 6th to the 9th grades have specific pedagogical needs and the curriculum of Natural Sciences practiced in schools is far from the reality experienced in high schools, because it is based on the dialogues between disciplinary knowledge structuring the areas of Chemistry, Physics, Biology, Geology, and Astronomy. From this perspective, we analyze curricular matrices of Full Degree courses in Natural Sciences. We take into account the disciplinary areas contemplated, the formative axes and the diverse contexts of creation of these courses. The research on the training provided by these courses allowed us to draw points that differentiate and characterize this type of professional development.

Keywords: professional development of teachers, natural sciences

UM ESTUDO SOBRE LICENCIATURAS EM CIÊNCIAS DA NATUREZA NO BRASIL

RESUMO: Neste artigo, discutimos a formação acadêmico-profissional de professores de ciências para atuar no ensino fundamental. Consideramos que o docente que leciona nesse nível deveria contar com uma formação exclusiva, que atendesse as necessidades pedagógicas do ensino fundamental e que subsidiasse a concretização, em sala de aula, de um currículo de Ciências da Natureza baseado no diálogo entre os conhecimentos disciplinares estruturadores das áreas de Química, Física, Biologia, Geologia e Astronomia. Nesse sentido, analisamos as matrizes curriculares de cursos de Licenciaturas Plenas em Ciências da Natureza. Consideramos as áreas disciplinares contempladas, os eixos formativos e os diversos contextos de criação dos cursos. A investigação sobre a formação proporcionada por esses cursos possibilitou que traçássemos pontos que diferenciam e caracterizam esse tipo de formação.

Palavras-chave: formação de professores, licenciaturas, Ciências da Natureza

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UN ESTUDIO SOBRE LICENCIATURAS EN CIENCIAS DE LA NATURALEZA EN BRASIL

RESÚMEN: En este artículo, discutimos la formación académico-profesional de maestros de ciencias para trabajar en educación primaria. Creemos que el maestro que enseña a este nivel debe tener una capacitación exclusiva que satisfaga las necesidades pedagógicas de la educación primaria y que apoye la realización, en el aula, de un plan de estudios de Ciencias Naturales basado en el diálogo entre el conocimiento disciplinario estructurante de Química, Física, Biología, Geología y Astronomía. En este sentido, analizamos las matrices curriculares de los cursos de Licenciatura en Ciencias Naturales. Consideramos las áreas temáticas cubiertas, los ejes de capacitación y los diferentes contextos para crear los cursos. La investigación sobre la capacitación brindada por estos cursos nos permitió extraer puntos que diferencian y caracterizan este tipo de formación.

Palabras clave: formación del profesorado, cursos de pregrado, Ciencias Naturales

INTRODUCTION

In Brazil, the first courses focused on teacher training began in the 1930s, the period when faculties of philosophy were created, aiming to expand studies at a higher level, not only with a professional focus, but also with the aim of replacing self-taught teachers, who were common at the time.

Science teachers intending to teach at the middle school were trained in natural history, but those with degrees in chemistry and physics could also study in this area, since there was a shortage of science teachers. Courses in natural history were offered by faculties of philosophy, and their curricula included the biological sciences and geosciences, among others.

However, Opinion no. 107/70 of the Federal Council of Education (CFE) pointed out that the curriculum of the Course in Natural History did not include subjects that would prepare its graduates for teaching science at the middle school. According to Tavares (2006), with this positioning, the CFE accepted a request from University of São Paulo (USP) and established the minimum curriculum for the Licentiate Degree in Biological Sciences.

Given this situation, courses in natural history have given way to courses in biological sciences when training teachers to work in middle school. Similarly, the courses in geology, chemistry, and physics did not offer a set of subjects that prepared their graduates to teach science at the middle school.

We must point out that the courses in biological sciences were the first to be regulated by the National Curriculum Guidelines, and the science curriculum of middle school was mostly composed of biology classes. However, for Ayres and Selles (2012, p.101), "even the changes that led to the emergence of the Licentiate Degree in Biological Sciences in 1963 did not fully take into account the specificity of science teaching."

Little by little, arguments in favor of the creation of a degree more focused on the teaching of middle school students that would address geoscience and biology content were put forward. For CFE, this degree would serve students who needed a teacher who had mastered the content necessary for teaching science and would mitigate the shortage of teachers in the field of middle school. In this context, the Short Licentiate Degree in Science was established, aimed at training professionals so that they would not become specialists, but professional educators with a more global perspective (TAVARES, 2006).

Among the three short licentiate degrees approved by Opinion no. 81/65, the Licentiate Degree in Science was the one that addressed the greatest shortage of teachers (TAVARES, 2006). However, the short duration of teacher training and the lack of interdisciplinary science courses, as opposed to the existing disciplinary courses in Physics, Chemistry, and Biology, caused some problems with the implementation of the short licentiate degree initiative due to issues regarding the versatility of teachers and the integration of sciences, since the public universities did not adhere to the project.

Other arguments were raised in academia against the short licentiate degree, especially during the 1980s, when opposition to these courses mixed with opposition to the military regime. After the fall of the military regime and the establishment of a new Federal Constitution in 1988, a new Law of Guidelines and Bases was drafted in 1996. Article 62 establishes the mandatory nature of the Full Licentiate Degree for professionals teaching in the field of Basic Education.

With this new determination, the higher institutions offering Short Licentiate Degrees in Science with qualifications had to adapt their curricula to offer full licentiate degrees. In this context, some institutions chose to offer full licentiate degrees in chemistry, physics, mathematics, and biology, because these subjects already had established national curricular guidelines. We must point out that, during this period, the national curricular guidelines for the Full Licentiate Degrees in Natural Sciences (LDNCs) had not been established yet[3], a situation that continues till date.

It should also be noted that LDNCs have little influence in public universities, characterized by strong departments or institutes in the areas of physics, chemistry, and biology. There is a prevalent feeling in these departments that the subjects of physics, chemistry, and biology in high school must have a propaedeutic character; that is, they must prepare students who will enroll in university courses in these areas. A series of investigations shows that the scientific subjects taught in high school are much different from those practiced in these professional institutions, since they incorporate important themes and movements like constructivism, science, technology and society, teaching through research, and the like, that are disregarded in these institutions.

Currently, teacher training for middle school takes place predominantly in programs for Licentiate Degrees in Biological Sciences. However, during the 1990s and 2000s, a new LDNC emerged, and some institutions still allow an undergraduate to pursue a qualification in chemistry, physics, and biology (for high school) and mathematics (for middle school).

LICENTIATE DEGREES IN NATURE SCIENCES

According to data from the Ministry of Education (MEC) obtained from the e-MEC system in the second half of 2017, there were 692 licentiate degrees in biological sciences, 48 licentiate degrees in natural sciences, and 14 licentiate degrees in nature sciences awarded in Brazil. Considering the degrees in natural sciences and nature sciences, 62 courses are aimed at training science teachers to teach in middle school. These licentiate degrees are offered by eighteen state and federal public institutions throughout the nation.

When we look at the number of licentiate degrees in biological sciences in relation to the number of LDNCs, we note that the training of science teachers to teach exclusively in middle school is less prevalent. Even so, LDNCs are offered in all regions of the country, especially in the Northeast and North regions, according to the information obtained from the e-MEC system. In these regions, eleven institutions offer courses on university campuses, at federal institutes, and at distance learning centers.

We observed a low number (4 institutions) offering LDNCs in the Southeast region, even though it is the region with the most developed universities in the country. This leads us to think that universities with highly developed Institutes of Physics, Chemistry, and Biology are not interested in offering this type of degree, because it requires an interdisciplinary, integrated effort. In such cases, emphasis is placed on bachelor's degree courses, and licentiate degrees are offered as a complement. However, as bachelor's degrees in nature sciences are rarely offered, and this subject is not offered in high school, there is a lack of interest in implementing this course in large centers.

We believe it is necessary to investigate the training of the professional who teaches science in middle school, because according to Razuck and Rotta (2014), at this level, students have different educational needs from that of students in high school. At this stage, teachers deal with aspects related to youth that are characteristic of a period of transition between childhood and adolescence, which influence, or should influence, the way they plan their classes. Moreover, at this stage of schooling, unlike in high school, training is not propaedeutic, because it does not only aim at preparing the student for a more advanced level, but at inserting him into the scientific culture. Moreover, at this level, the focus is not on establishing relationships with the world of work, as occurs in high school.

During middle school, students have access to different ways of thinking and communicating that originate in different fields of knowledge, thus expanding their ability to communicate. However, in the case of nature sciences, there is still no disciplinary specialization, which requires a great effort from teachers to integrate the different knowledge of the subjects that make up this area to configure an objective and interdisciplinary look at the phenomena being studied. Thus, the teacher should approach the phenomena in an unrestricted manner, allowing all the issues arising from the various fields (chemistry, physics, biology, astronomy, and geology) to illuminate his approach without allowing one area to stand out from the others, as usually occurs today.

In order to satisfy all these training needs, the teacher should have an exclusive type of training that facilitates the implementation of a curriculum of natural sciences based on the dialogue between the disciplinary knowledge structuring the areas of chemistry, physics, biology, geology, and astronomy in the classroom.

Therefore, we hypothesize that the LDNCs that do not qualify for the chemistry, physics, biology, and mathematics areas, because they are not linked to the bachelor's degree modality, can enable the study and integration of the disciplinary areas that make up the science curriculum in middle school with pedagogical knowledge.

Thus, we present an analysis of the curricular matrices and syllabi containing the subjects of LDNCs that enable their graduates to act exclusively in the context of middle school. We considered the disciplinary areas that were covered and the various contexts in which these courses were created. We aimed to show which disciplinary areas were contemplated and how they were offered in the various training courses that were analyzed, tracing points of convergence and divergence between them. We did not aim to establish comparisons to indicate which would be the best training model, but to list elements that would allow us to reflect on the training of science teachers to teach at the middle school.

METHODOLOGY

In order to analyze the curriculum matrices of LDNCs and the syllabi of the subjects offered, we started with data collected from the e-MEC system. From all the courses offered by public higher education institutions in 2014, we selected the twenty licentiate degrees aimed at training science teachers for middle school. Soon after, we searched the websites of the institutions and, in some cases, the pedagogical projects, matrices, and syllabi of the selected courses, reaching a total of 14 licentiate degrees.

First, we read the names of the subjects and created thematic categories, which were defined afterwards. We then assigned each subject to a thematic category, and when the syllabus of the subject left us in doubt as to which category it fell into, we proceeded to read the syllabus. In total, we established the fifteen categories of analysis described below:

1- Biology (BIO): Includes courses/subjects that address biological knowledge, such as zoology, evolution, and genetics, for example.
2- Physics (PHY): Includes courses/subjects that approach physical knowledge, such as Physics I, Physics II, mechanics, electromagnetism, and the like.
3- Chemistry (CHE): Includes courses/subjects that address chemical knowledge, such as inorganic chemistry, organic chemistry, and the like.
4- Mathematics (MAT): Includes courses/subjects that address the mathematical knowledge taught in the courses, such as Calculus I and Calculus II, for example.
5- Geosciences (GEO): Includes courses/subjects that relate to the study of the earth, its constitution, and its origin, such as geology, mineralogy, and astronomy, for example.
6- Portuguese (POR): Includes courses/subjects that introduce Portuguese, or basic Portuguese, such as Reading and Textual Production, for example.
7- Informatics (INF): Includes courses/subjects that introduce computational resources, such as Introduction to Informatics and Basic Microinformatics, for example.
8- Statistics (AE): Includes the courses/subjects that address statistical knowledge when applied to nature sciences.

9- Content Pedagogical Knowledge (PCK): Includes courses/subjects that promote the integration of the knowledge of disciplinary content and pedagogical knowledge. For example, we might mention Specific Didactics, Methodology of Science Teaching, Instrumentation for Science Teaching, Teaching in Science Teaching, School Culture and Scientific Culture, and Education in Science in Formal and Non-formal Spaces (among others).
10- Meta-scientific (MET): Includes courses/subjects that promote a critical reflection on science through discussions that consider its historical and philosophical character, its dissemination, and its insertion into, and presence in, the current social context. For example, we might mention History of Science; Philosophy of Science; Scientific Dissemination; and Science, Technology, and Society (among others).
11- Pedagogical knowledge (PED): Includes courses/subjects that address the foundational pedagogical knowledge for teaching, such as Philosophy of Education, Psychology of Education, Assessment and Curriculum, and Public Policy, for example.
12- Internship (MI): Includes the courses related to supervised internship that are present in the program.
13- Libras (LIB): Includes the courses/subjects related to the study of Brazilian sign language when applied to teaching.
14- Electives (ELE): Includes the required elective courses that students must take in order to graduate.
15- Final course work/final project (FCW): Includes courses that provide guidance on the final course work or final project.

We counted the workload of each subject that comprised each category and obtained the proportion, in hours, for each category. Secondly, we grouped these categories on two formation axes: (i) disciplinary content, which involves approaches to the subjects that constitute the area of nature sciences and that enable teachers to teach the content (thus, on this axis, we included subjects belonging to thematic categories 1 to 5, as described above); and (ii) pedagogical content, content pedagogical knowledge, and supervised internships, which relate to the training of the teacher, as these areas promote approaches to several teaching skills necessary for the training of teachers. On this axis, we included the subjects belonging to thematic categories 9, 11, and 12, described above.

We aim to promote a discussion on the articulation between these two axes of teacher training, having as its basis the discussion in the teacher training literature related to the formula known as "3 + 1." Thus, we are interested in knowing whether the courses we analyzed exceed the characteristics of this formula. Therefore, the subjects belonging to thematic categories 6, 7, 8, 13, 14, and 15 will be absent from this discussion.

THE COMPOSITION OF THE CURRICULUM MATRICES OF LDNCS

In our research, we observed that the courses were offered by institutions founded in the 2000s and/or by those that expanded with the creation of new campuses in less-developed areas of the metropolitan regions or the hinterlands of the Brazilian states. These regions, in most cases, were chosen with the aim of promoting the social development of local communities where there was no public HEI presence. Many of these institutions have joined the Plan of Reorganization and Expansion of Federal Universities (REUNI), which began in 2003. In other cases, the LDNC was offered in accordance with the National Plan for Teacher Training in Basic Education (PARFOR).

As we will see below, the analysis of the matrices reveals several possible compositions. We found courses of study that offered subjects in all the categories listed above and courses that privileged some areas of knowledge to the detriment of others. We believe that this diversity is mainly due to the lack of a Curriculum Guideline for this type of teacher training.

We chose to present the analysis of the fourteen curricular matrices according to the distribution of licentiate degrees in the five Brazilian regions, presenting the data by region as it was done in the reports and studies of the Ministry of Education and the studies on teacher education in Brazil (GATTI and NUNES, 2009). We believe that, in this way, we are creating a dialogue with the studies developed by the MEC and the other research that presents the reality of Basic Education and teacher training.

Training paths proposed by region.

In this section, we present the analysis of the curricular matrices and syllabi available on the websites of the institutions. We understand that the curriculum is "[...] a discursive practice. This means that it is a practice of power, but also a practice of meaning, of attribution of meanings" (LOPES and MACEDO, 2011, p. 41). Therefore, we read the history of creation of the courses described in the pedagogical projects and on the institutional websites because we wanted to understand the functioning and the institutional context in which the subjects that we analyzed were managed. Thus, for each region, we prepared a brief history of creation of the courses we analyzed and the grouping of all subjects offered in the categories that we previously defined. All the curricular matrices that we analyzed were from 2014.

- South region

According to our research, this region had courses that enabled teachers to teach science only in middle school and courses with qualifications in the areas of science, chemistry, biology, and physics. Of the institutions registered in the e-MEC system, we analyzed the curricular matrices of four: the State University of Maringá (UEM), the Federal University of Fronteira Sul (UFFS)[4], the State University of Paraná (UNESPAR), and the Federal University of Pampa (UNIPAMPA). The courses offered by these institutions were offered predominantly at night on campuses in cities far from the state capitals, in border regions. Except for the UEM course that was established in 1991, the others were implemented from the 2000s onwards. UNESPAR's licentiate degree has been offered since 2000, and the licentiate degree of UFFS has been offered since the creation of the university in 2009, as is also the case at UNIPAMPA, which was founded in 2008.

In the courses analyzed in the South region (table 1), the high workload of subjects addressing biological knowledge compared to the workload devoted to the areas of physics and chemistry is noteworthy. In almost all the cases, the latter had the same workload, except for at UNIPAMPA.

Table 1: Distribution of course hours by category for each institution in the South region.

Workload by category for each institution in the South region (in hours)															
Institutions (abbreviation)	Categories														
	Bio	Phy	Che	Mat	Geo	Por	Inf	Ae	Pck	Met	Ped	Mi	Lib	Ele	Fcw
UEM	408	272	272	272	136	-	68	-	238	272	408	510	68	-	272
UFFS	450	300	300	120	105	120	60	60	285	180	345	420	60	120	90
UNESPAR	680	408	408	544	68	-	34	-	68	68	136	408	-	-	-
UNIPAMPA	630	360	570	60	60	60	-	30	180	60	660	420	60	-	60

Source: Adapted from REIS (2016).

All courses of study offer subjects in the category of mathematics. At some institutions, such as UEM and UNESPAR, the workload in this category is equal to or greater than those of chemistry and physics. At most institutions, the category of mathematics has a considerably higher workload than that of geosciences, which covers knowledge that makes up the science curriculum in middle school. If we compare the emphasis on mathematical knowledge with the offerings in the Final Course Work category, we see that the former is more valued than the latter, because FCW is not present in all the courses we analyzed.

Regarding the category of geosciences, as we moved through the analysis of institutions, the workload decreased. It required a lower workload than the categories of physics, chemistry, and biology. In most of the courses we analyzed, only one subject discusses geosciences with the students. This decrease is also observed in the workload devoted to the meta-scientific category subjects.

Regarding the knowledge required for teaching, the pedagogical content knowledge category required a lower workload than the pedagogical category.

- Midwest region

In this region, most of the courses only confer a qualification for nature sciences. We obtained the curriculum matrices of two institutions, the Federal Institute of Technological Education of Mato Grosso (IFET-MT) and the University of Brasília (UnB), from their websites (Table 2).

This course of study that has been offered by IFET-MT since 2010, and it takes place at night in the city of Jaciara, in the hinterlands of the state, at an advanced center of the São Vicente Campus. The center was created to meet a demand for science teachers in the region.

The University of Brasilia, in contrast, was created over 50 years ago and is considered a traditional Brazilian higher education institution. Around 2005, it developed an expansion plan involving the creation of new campuses and later joined the REUNI. An LDNC has been offered since 2006 at the Planaltina-DF campus, and both day and night classes are currently offered there.

Table 2: Distribution of course hours by category for each institution in the Midwest region.

Workload by category for each institution in the Midwest region (in hours)															
Institutions (abbreviation)	Categories														
	Bio	Phy	Che	Mat	Geo	Por	Inf	Ae	PCK	Met	Ped	Mi	Lib	Ele	FCW
IFET-MT	640	400	360	280	40	80	-	80	280	160	320	400	40	160	80
UNB	300	240	270	60	270	-	-	60	180	60	240	405	60	660	60

Source: Adapted from REIS (2016).

According to the data on Table 2, the courses we analyzed have very distinct curricular matrices. In IFET-MT, the workload of the biology category is higher than those of the others. The mathematics category, with 280 hours of course work, is more highly valued than the geosciences category (40 hours), as was also the case in the South region.

The UnB course has a more even workload distribution between the categories that compose the disciplinary axis, such as biology (300 hours), physics (240 hours), chemistry (270 hours), and geology (270 hours). The data are interesting because they show that, in this curriculum matrix, none of the categories is valued more highly than the rest. This reaffirms the importance of the future teacher of natural sciences having access to knowledge from all areas and that this contact is not restricted to an "example" of knowledge from one particular area in the science curriculum. On the contrary, it can be expected that such contact with a wide range academic fields will enable the student to reflect on the disciplinary knowledge present in the teaching of science and develop a more integrated view of these areas.

Another relevant point is the workload of elective subjects (660 hours) which, according to the pedagogical impetus of the course, aims to give students the opportunity to complement their studies with courses in the areas that interest them most, either to prepare them for further study, or because they are experiencing academic difficulties and want/need to improve themselves. The high workload of elective subjects in the UnB licentiate degree program may be the reason that the pedagogical content, meta-scientific, and pedagogical categories require a lower workload at UnB than at IFET-MT.

- Southeast region

In the Southeast region, the only states with institutions offering an LDNC are São Paulo and Rio de Janeiro. Unlike the other regions, the institutions in the Southeast only offer on-site courses. Of the on-site courses, three do not offer specific qualifications in chemistry, physics, or biology. Of these three courses of study, two were used for this study (table 3), as they made the matrices available on their institutional websites: one at the Federal University of the State of Rio de Janeiro (UNIRIO), and the other at the University of São Paulo (USP).

We noticed a high workload in the geosciences category at USP and in the biology category at UNIRIO. However, we must consider the context in which these licentiate degrees are offered, as this may be reflected in the development of the curriculum matrices and would explain the concentration of subjects in some areas.

Although the LDNC at UNIRIO was implemented in 1984, it was transformed in the 1990s into a pedagogical complement to the bachelor's degree in biology. However, according to the pedagogical project, and in compliance with the new National Curriculum Guidelines for Undergraduates, the course was restructured and was offered again in 2007.

USP's LDNC course was implemented in 2005, with the creation of a university campus in eastern São Paulo. When comparing the workload values of the chemistry (180 hours), physics (195 hours), biology (480 hours) and geosciences (450 hours) categories, greater emphasis was placed on the last two to the detriment of the first two. This may be because this institution hosted the first natural history course in Brazil. In these courses, aspects related to geosciences were studied, and this may have been reflected in the development of the proposed curriculum matrix for the course.

Table 3: Distribution of course hours by category for each institution in the Southeast region.

Workload by category for each institution in the Southeast region (in hours)															
Institutions (abbreviation)	Categories														
	Bio	Phy	Che	Mat	Geo	Por	Inf	Ae	PCK	Met	Ped	Mi	Lib	Ele	FCW
UNIRIO	705	165	120	120	270	-	-	60	240	-	270	410	60	-	60
USP	480	195	180	180	450	-	-	60	360	60	240	400	-	-	300

Source: Adapted from REIS (2016).

- Northeastern region

In 2014, the Northeast region had 10 LDNCs, most of which were implemented in the 2000s. Of these, five did not confer qualifications in other areas, and we obtained data from four of these institutions. The institutions whose curricular matrices we analyzed were the Federal University of the Vale do Rio Francisco (UNIVASF), Federal University of the Recôncavo Baiano (UFRB), Federal University of Paraíba (UFPB), and Federal University of Piauí (UFPI). A distinctive feature of this region is the availability of distance learning courses (UFPB) and in the scope of PARFOR in the modality of a first degree for teachers who already work at educational institutions without academic training in the area in which they teach, as is the case in the UFRB's course of study.

Among the degrees offered in the Northeast region (Table 4), the UNIVASF course has the highest workload in the geosciences category (180 hours) and in the meta-science category (300 hours). The latter corresponds to the highest workload in this category among all the matrices analyzed in the research. We must also highlight the fact that the workload of the pedagogical content knowledge category (360 hours) at this institution is three times higher than that of the pedagogical knowledge category (120 hours).

Among all the matrices analyzed, the course of study with the highest workload in the area of pedagogical knowledge is the one offered at UFPB (675 hours). If we compare the institutions of the Northeast region, the UFPB's LDNC has a smaller discrepancy between the biology, physics, chemistry, and geosciences categories than the other courses of study in this region that we analyzed. However, we observed, as in the other courses in other regions that we analyzed, there is a heavy workload in the biology category (629 hours) at UFRB's LDNC, especially when we compare this workload with those in the areas of physics, chemistry, and geosciences.

The UFPI's course is the only one in the Northeast region that does not include any subjects in the geosciences category. On the other hand, it requires a workload in the mathematics category (300 hours) equal to that of the chemistry category (300 hours), which leads us to reflect on the degree of importance given to mathematical knowledge.

When we analyzed the courses in the Northeast region (Table 4), we observed that most of them valued the subjects in the pedagogical content knowledge category highly. In general, the subjects that address knowledge of biology are more valued than those addressing chemistry and physics. The geosciences category does not have as much importance as the others. In fact, at the institutions where courses in geosciences are offered, this area requires a lower workload; UFPI, however, does not offer any subjects in this category.

Table 4: Distribution of course hours by category for each institution in the Northeast region.

Workload by category for each institution in the Northeast region (in hours)															
Institutions (abbreviation)	Categories														
	Bio	Phy	Che	Mat	Geo	Por	Inf	Ae	Pck	Met	Ped	Mi	Lib	Ele	Fcw
UNIVASF	450	300	240	120	180	-	-	-	360	300	120	420	60	60	90
UFRB	629	204	238	85	68	-	68	51	255	-	374	408	68	-	102
UFPB	285	225	225	120	120	60	45	-	270	-	675	405	-	120	120
UFPI	480	360	300	300	-	60	60	-	360	60	360	405	-	150	60

Source: Adapted from REIS (2016).

- North Region

In the North region, half of the LDNCs did not provide qualifications for other areas. We obtained data from two institutions (Table 5): the Amapa State University (UEAP) and the Federal University of Pará (UFPA).

The results of the analysis of the courses in the North region do not differ from those of the other regions. We observed a higher workload in the biology category than in the physics, chemistry, and geosciences categories. We observed that the courses in this region that we analyzed have a heavier workload in the pedagogical content knowledge area than those we found when analyzing other regions. We observed that the geosciences category required a low workload and the mathematics category was more highly valued in terms of hours/classes.

Table 5: Distribution of course hours by category for each institution in the North region.

Workload by category for each institution in the North region (in hours)															
Institutions (abbreviation)	Categories														
	Bio	Phy	Che	Mat	Geo	Por	Inf	Ae	Pck	Met	Ped	Mi	Lib	Ele	FCW
UEAP	760	280	420	140	60	60	60	60	520	100	520	400	120	-	120
UFPA	544	340	408	136	136	-	68	-	408	-	68	408	34	-	68

Source: Adapted from REIS (2016).

In general, we have not found a homogeneous distribution of the workload among the several areas we have chosen as categories. Again, we reiterate that this may be due to the absence of established national curriculum guidelines for LDNCs. However, we can take a new look at the curriculum matrices and analyze them by grouping these categories in relation to the (i) approach of the disciplinary content and (ii) of the pedagogical content, pedagogical content knowledge, and training during supervised internships to promote a discussion on the articulation between these two axes of teacher training.

An overview of the curricular structuring of the LDNCs we analyzed

With regard to the curricular organization of teacher training courses, it can already observed from the literature (DINIZ-PEREIRA, 1999; GATTI and NUNES, 2009; CARVALHO and GIL-PÉREZ, 2011) that the first licentiate degrees were based on the "3+1" formula, in which the disciplinary content, under the auspices of the basic institutes, was taught during the first three years of the course of study and the pedagogical content was addressed in the last year as a complement to the bachelor's degree. In this proposal, there was no articulation between the pedagogical training and the content that was taught, converging in a training model based on technical rationality. Moreover, there was no concern shown for addressing the pedagogical knowledge of the content that was taught.

An attempt was made to reverse this situation with the establishment of the National Curriculum Guidelines for the training of teachers of basic education, through CNE/CP Resolution No. 1 of 2002, which led to a reform of the curriculum matrices of various licentiate degrees. This occurred because, among other goals, a more dialogical training between the formative axes was desired, not only a change in the distribution of the workload, although this was also intended.

In order to see if the Licentiate degrees in Nature Sciences that we analyzed deviated from this "3+1" formula, we present in Table 6 the percentage of the total workload devoted to the subjects in which specific content is taught and the percentage of the subjects aimed at teaching preparation (pedagogical knowledge, pedagogical content knowledge, and internship).

Observing the data in Table 6, we can see that none of the curricular matrices that we analyzed fit the "3+1" formula. In general, we can say that there is a certain balance in the distribution of course hours between the disciplinary formation and preparation for teaching axes.

Table 6 - Percentages of the categories focused on disciplinary knowledge and those focused on teacher preparation.

Region	Institution	Sum of the percentage of the categories in relation to the total workload of the course	
		Chemistry, Physics, Geology, and Biology	Pedagogical Knowledge, Pedagogical Content Knowledge, and Internship
South	UEM	31,7%	33,6%
	UFFS	37,6%	34,2%
	UNESPAR	51,7%	20,2%
	UNIPAMPA	47,0%	36,5%
Midwest	IFET-MT	45,6%	31,7%
	UnB	34,4%	26,2%
Southeast	UNIRIO	42,0%	30,7%
	USP	35,5%	27,2%
Northeast	UNIVASF	37,3%	28,7%
	UFRB	40,4%	36,8%
	UFPB	28,2%	44,6%
	UFPI	35,8%	35,3%
North	UEAP	36,9%	34,9%
	UFPA	48,3%	29,9%

Source: data taken from REIS (2016).

In most of the courses, between 30% and 40% of the total workload is devoted to subjects in the chemistry, physics, biology, and geosciences categories, which are content subjects, with an emphasis on biology. In general, the chemistry and physics subjects have a workload close to, but lower than that of, biology; the subjects in the geosciences category have an even lower workload, as previously discussed.

Regarding teaching preparation, in seven of the fourteen courses analyzed, the workload of subjects in the pedagogical knowledge category accounts for up to 10% of the total workload of the courses. In the other seven, they account for between 11% and 22% of the total workload. However, when we analyzed the workload of subjects in the pedagogical content knowledge category, we observed that in most courses of study (10), they account for less than 10% of the total workload.

It is important to emphasize that we expected a considerable presence of subjects addressing pedagogical content knowledge, since they favor the integration of the knowledge of disciplinary content and pedagogical knowledge. According to indications from the field of science teacher education (CARVALHO and GIL-PÉREZ, 2011), the approaches used in these subjects are aligned with the integration of knowledge incorporated by graduates throughout training, through reflections on the transposition or didactic recontextualization of how to learn to learn, and on how to teach science.

Finally, another aspect that is not described in Table 6, but that caught our attention, is the presence of meta-scientific subjects in ten of the fourteen courses analyzed. According to Schnetzler (2012, p. 97), the literature indicates that besides knowing the content to be taught, teachers must have knowledge of the history and philosophy of sciences; the methodological guidelines that shape the construction of scientific knowledge; the interactions between science, technology, society, and the environment; and the limitations of, and perspectives on, scientific development. All this knowledge can serve as the basis of a teaching process in which the content is not approached as ready, true, static, unquestionable, and neutral or socially, historically, and culturally decontextualized.

IMPLICATIONS FOR TEACHER EDUCATION AND FINAL CONSIDERATIONS

Several studies (LIMA and AGUIAR, 2000; LOPES and MACEDO, 2002; MARTINS *et al.*, 2003; AYRES *et al.*, 2012; LIMA and SILVA, 2012; REIS, 2016) have shown the integrative nature of the subject of nature sciences in middle school because its curriculum is structured around the knowledge of different subject areas (chemistry, physics, biology, astronomy, and geology).

Added to this fact, throughout this work, we sought to show how the pedagogical knowledge, pedagogical content knowledge, and meta-scientific subjects have been valued in the courses that we analyzed. This indicates a movement in licentiate degrees in nature sciences towards an academic-professional training regimen that can introduce the teacher into a new way of thinking about teaching and that allows for learning that breaks with reductionist views: that teaching should be primarily focused on biology, that teaching is easy, that there is a unique and true scientific method, that middle school is only a period of transition to high school, and so many other views that permeate attitudes toward this stage of schooling.

Teachers who work in middle school, as well as teachers who work in any other area, have their own views about what it is to teach and how to learn based on their previous experiences in basic education and their academic and professional training.

However, it is not possible to state that there is an articulation between the formative axes and how it occurs in the analyzed matrices. We believe that the courses mentioned in this study give us evidence that our initial hypothesis – that the LDNCs that do not confer qualifications in the areas of chemistry, physics, biology, or mathematics, because they are not linked to the bachelor's degree modality, would allow a greater integration between the training axes investigated – is partially confirmed, because there is a tendency of differentiated training to generate greater integration between disciplinary areas, pedagogical knowledge, pedagogical content knowledge, and supervised internships. This aspect of science teacher training will require further study and analysis in future research.

This entire movement is a rich territory for further study because it allows us to rethink the selection and organization of the curricula that are used, what constitutes the identity of the teacher who engages in the teaching of science at the middle school, and their knowledge and history.

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NOTAS

[3] We will use the abbreviation LDNC every time we refer to the Licentiate Degree in Science, Licentiate Degree in Natural Sciences, and Licentiate Degree in Nature Sciences that are aimed at training science teachers to work exclusively in secondary education.
[4] In 2015, when we finished collecting data, the Licentiate Degree in Nature Science is not offered anymore at the University of Fronteira Sul. In its place, the university now offers degrees in chemistry, physics, and biology.

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