

DEFINING MATH TEACHERS' KNOWLEDGE:

discussion about examinations for elementary and secondary teachers in Brazil in the nineteenth century

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ABSTRACT

Educational reforms require an evaluation of all the elements which have to do with the school environment, such as students, textbooks and teachers, among others. It is common sense that a good teacher is essential to the improvement of any subject. But how can one measure the teacher's "quality"? In Brazil, one of the conditions for the recruitment of teachers for primary and secondary public schools is the public contest. The first actions in this sense date from 1759 and substituted the religious' classes for isolated ones given by improvised teachers, with no diploma requirement. Throughout the century teaching reforms adopted different selection processes, training and admission of future teachers. As years went by the examinations became more comprehensive, thus demanding more specific knowledge besides written and oral exams from the teachers. This text aims at discussing the teaching of Mathematics in Brazil during the 19th century through contests for teachers taken place in Rio de Janeiro (Brazil) and raise further questions about the selection of teachers and the contents which are required in order to occupy such positions, thus providing other researchers with materials for comparisons with models originated in other countries.

1 Introduction

In Brazil, training at a higher education level in order to graduate teachers to act in the primary and secondary schools starts with the creation of universities, which took place behindhand from the 1930s on. As there were no institutions which offered specific education for a Mathematics teacher in the 19th century, any professional with technical background could teach. Furthermore, as far as the first grades were concerned, no particular training was required, as very little was expected from the candidates.

Even with such a gap during the 19th century, beginning of the institutionalization of the public instruction in Brazil, other mechanisms regulated the teaching practice and legitimated the range of knowledge necessary for whoever wanted to be a teacher. Such mechanisms were usually limited to "certificates of good conduct" and "knowing the content", not being necessarily required any specific training or course for such a position, not even certificates of previous educational background.

Jesuit priests were the first teachers in Brazil, having arrived to the country in 1549 with the mission of catechizing the native inhabitants. Jesuit teaching, restricted to "reading,

writing and counting” spread gradually, starting a period of almost two centuries in which the schools directed by the religious were the only ones in Brazil where there was no knowledge of the existence of formal policies for the selection of teachers. After the Jesuit banishment in 1759, the State became responsible for the teaching system. Throughout the 19th century, several legal apparatuses regulated the teaching profession and the conditions for public and private teaching practice in Brazil. According to the current regulation, these conditions were altered in many ways, granting more or less freedom to the practice of the profession, as it can be read from the texts of the legislation.

The modern teacher, despite being quite different from the 19th century one, still deserves studies which seek to understand the constitution of their profession and the characterization of the knowledge they possess.

In his considerations of possible approaches of the history of Mathematics teaching, Schubring (2005) recalls two of its traditional branches: analysis of the teaching programs and analysis of government decrees, where the latter is frequently linked to the former one. Other two subjects are recalled by the author as items which determine the reality of Mathematics teaching more accurately: school manuals and the Mathematics teacher.

According to Schubring (2005) the teacher *“does not constitute a passive subject who receives and applies the programs, but represents the decisive person in the process of learning”*, thus being configured as *“the best means in order to gain access to the historical reality of teaching”* (p.9). The author distinguishes four dimensions which will give access to this reality, as follows: the systems of teacher education; the conceptions of the competencies which the future teacher must acquire; the education institutions; and the professional background of the tutors in these institutions.

Which instruments can be used in order to rebuild the teacher’s professional trajectory and their practices? By making use of which elements can we examine the questions related to the access to the Mathematics teaching profession throughout the 19th century? How can one identify which range of knowledge those candidates had or should have so that they could put the teaching profession into practice?

Based on the importance of a deep analysis of the teacher recruitment question so that *“one can conceive what the culture of the ideal teacher in the 19th century is”* Julia (2001) recommends taking three items into account:

[...] the evolution of the authors when it comes to the program of the examinations and the contests and the exams which were actually applied, the performances genuinely achieved by the candidates [...] and the examining board reports, which make a statement about the examiner’s expectations and wishes – whether fulfilled or not (p.31).

In the light of such items, it is believed that the public contest examinations can reveal the actual requirements for the teaching practice, not to mention other significant questions about the conception related to the teacher’s role, the contents they were supposed to teach, the knowledge they should possess, among other aspects, in those times.

In a very popular article published in 1986, Lee Shulman starts by making some comments about a quotation by Bernard Shaw which questions the (in)capacity of teachers: *“He who can, does. He who cannot, teaches”*). In order to discuss possible origins of such a

quotation, Shulman (1986) holds exams for teachers applied in the state of California in 1875 as example.

In the shape of Lee Shulman (1986)'s article, this text aims at covering aspects of the history of Mathematics teaching in Brazil during the 19th century, discussing the selection of teachers and the evolution of the range of knowledge required from the teaching candidate by making use of exams for admission of teachers applied in Rio de Janeiro. As well as in Shulman (1986), public contest examinations applied in Rio de Janeiro during the 19th century found in the city's archives are used for analysis so that it can provide researchers in history of the Mathematics teaching with materials for possible comparisons with models from other countries.

Most of the consulted material was found at *Arquivo Geral da Cidade do Rio de Janeiro* (General Archive of the City of Rio de Janeiro) and at *Arquivo Nacional* (National Archive). These documents contain the required contents in every examination, information about the candidates, the list of the examiners in all held contests and the final considerations of the examining board.

2 Teaching in Brazil in the 19th century and the selection of teachers

The existence of several types of teaching can be taken into account in Brazil in the 18th and 19th centuries, organized according to Vasconcelos (2004) into three great education modalities:

Public teaching – refers to the one offered in schools provided by the State or by “subordinate associations to it” [...].

Private teaching – refers to one which was offered in private schools or teachers' homes, who received children and youngsters in order to teach them the established subjects.

Home teaching – the one which took place at the learner's home, in the private sphere, in which parents hired of their own free will the teachers, thus determining the contents and abilities to be taught to their children at the time and conditions exclusively set (p.43).

The teachers of the first two modalities needed an authorization to teach. The teaching selection process took place in the shape of a public contest, where an examining board awarded a teaching license, or not, after watching the candidate's exams (CARDOSO, 2002).

As it has already been said, several laws ruled public teaching in Brazil and established policies for the teaching selection process throughout the 19th century. Among the main legislation norms which ruled the country's instruction in the aforementioned period there were some permits dating from the 18th century and the laws from 1827 and 1854 (Couto Ferraz Reform). Each one of these laws or reforms established the contests' conditions by either determining the dynamics of their examinations or specifying the contents on which the teachers should be tested. Some of these are shown, as follows. The contents of the examinations will be discussed in 2.2.

2.1 Norms for teacher selection

The first measure which was adopted by the King of Portugal in order to care for studies in Brazil after the Jesuit banishment was established by the permit from 28th June, 1759. This permit stated that the responsibility for public instruction laid in the hands of the *Diretor de Estudos (Director of Studies)*, nominated by the king and to whom all the teachers were subordinate. The permit offers dispositions of the attributions which teachers of some subjects had but very few considerations are given about the creation of schools and the provision of teachers for classes of first letters (*reading, writing and counting*) and the Science field.

In this period a few people were licensed to work as teachers in Brazil. Probably these teachers had just been chosen and nominated among those who either already worked as such or were willing to do it. Actually, after the Jesuit banishment, classes of first letters kept on being taught by improvised teachers, either in the domestic sphere or in the religious institutions which were still found in Brazil. Other more specific norms were only formally established with the permit from 6th June, 1772, which creates classes of First Letters, Latin Grammar and Greek Language in the city of Rio de Janeiro and in other locations. This document created schools and determined the necessary steps to the adequate provision of teachers, including publishing contest description, applying examinations and having teachers to send class reports at the end of every school year.

After the contest description publishing, informing of the existence and location of the vacancy, the candidate made a solicitation, introducing themselves and requesting their enrollment in the contest. Along with this solicitation, the candidate showed certificates of good conduct provided by the priest, police or another local authority, thus attesting their good reputation. Other certificates and information could also be displayed confirming the candidate's teaching experience, courses possibly taken, previous job positions or any documents which could prove them a good candidate before the contest examining commission. Despite all this, the candidate was not expected to produce any proof of previous educational background; "knowing the content" and passing the exam were enough to take up the position.

After displaying all the documents the candidate needed to pass the written exam. For this level the exam simply consisted in a single question of arithmetic and an evaluation involving spelling. The examining board would correct the exams on the same day or on the following one and write brief proceedings confirming the performance of the candidate and entitling them or not to the vacancy. In this period, there were few teachers and the contests did not occur regularly.

As for the elementary instruction after the Royal Family's coming to Brazil in 1808, D. João VI kept the current conditions basically unchanged in terms of the dynamics of teacher hiring. For instance, he authorized the verification of subjects which had no teachers and the organization of examinations for teacher hiring. In the same year, the government would pronounce, similarly to a previous document (1799's Carta Régia / Royal Letter), on the decision to create the Arithmetic, Algebra and Trigonometry subjects in Rio de Janeiro, highlighting the importance of the Mathematics studies by the decree of 17th January, 1809:

[...] being the study of mathematics the most important to all classes of people who wish to be distinguished in the various occupations and employments of society, either scientific or mechanical; it is essential that, at least, its elements or first branches, such as arithmetic, algebra, theoretical and practical geometry, become vulgar and constitute in one of the first instructions of youth; for such justified reason there should be created the first aforementioned subject, in which one will be taught arithmetic until quadratic equations inclusively; theoretical and practical geometry and trigonometry.

The document also recalls teachers should teach:

[...] numerical calculus along with the algebraic one temporarily, both from whole and fractional quantities; solving linear and quadratic equations; exponentiation and square roots; theory of proportionality and progressions; rules of three; having as an end to the teaching of arithmetic and algebra the solving of the most usual problems faced in the trading business, such as the ones related to interest etc [...]

Later, soon after the Brazilian independence from Portugal, the law from 15th October, 1827, declares that there would be schools in all cities and most populated places. Besides, those schools should all follow the Lancasterian system. The law also foresees that the teaching candidates should take public exams. The candidates who did not master the system were supposed to take courses in schools from the capital at their own expense.

As for the subject, the law determines that:

Teachers will teach reading, writing, the four arithmetic operations, practice of fractions, decimals and proportionalities, general notions of practical geometry, the national language grammar, Christian moral and religious principles from the Roman Catholic Church doctrine[...] (Article 6).

Both male and female teachers will earn the same salary, whereas female teachers “*will not teach geometry notions but only the four operations*”, as it can be read in Article 6, and domestic chores as well.

Information about secondary education in Brazil can only be found from 1837 on due to the creation of Colégio Pedro II (Pedro II High School), the first public secondary school in the country. No contests were held in order to nominate its first teachers. Later, specific norms were established. Those were more demanding in relation to teacher hiring than the ones regulating primary education.

From the 1850s on the legislations for teacher nomination for both primary and secondary schools become ever-detailed and provide with more accurate information about the practice of contests and what should be required from the teaching candidates.

The reform carried out by *Luiz Pedreira do Couto Ferraz* approved two special documents in particular: *Regulamento da Instrução primária e secundária do Município da Corte* (Royal Municipal District Regulation on Primary and Secondary Instruction), in 1854, and *Instruções para a verificação das capacidades para o magistério, e provimento das cadeiras públicas de Instrução Primária e Secundária* (Instructions for the verification of teaching requirements and provision for the public subjects in Primary and Secondary Instruction, in 1855. Such documents declare that only Brazilians who can

produce proof of legal age of majority, morality and professional capability are allowed to teach. For the morality exams the candidate was supposed to display certificates from the places where they had lived in the last three years, besides priest declarations. Age of majority would be attested by a certificate. Professional capability should be established by oral and written exams on the teaching subject as part of a public contest before the *Inspetor Geral (General Inspector)* and two examiners nominated by the government. The examination should evaluate the candidate not only as far as knowledge of the subjects was concerned but also in relation to the *teaching method*.

As for primary schools teaching candidates should sit the following exams: Christian Doctrine, Sacred History, Reading and Writing, Portuguese Grammar, *Arithmetic*, *Imperial System of Weights and Measures*, Practical System and Teaching Methods. All exams were supposed to be taken within 4 hours. There would be written and oral exams and their content would be selected through a draw from formulated topics by the *Counseling Director* taking as reference the range of knowledge necessary to teach the subject. As far as secondary schools were concerned, the exam topics would be selected from the items in the Colégio Pedro II (Pedro II High School)'s official program. This time teachers would sit *Algebra*, *Trigonometry*, *Geometry* and *Arithmetic* exams.

2.2 The teacher of Mathematics' knowledge in Brazil during the 19th century

As Shulman (1986) highlights in his article, the teacher is expected to display knowledge of a certain subject as a prerequisite in order to teach it. What knowledge this should be, however, has been the center of hot discussions since the 19th century. On the other hand, a fundamental question which Shulman poses when searching for possible answers to Bernard Shaw's quotation, lies on how much the teacher knows about the subject they're going to teach. Not taking for granted the importance of other aspects which characterize the knowledge the teacher should possess in order to teach, such as the didactical methods, Shulman (1986) retakes exams applied in California in 1875 and compares their contents with the current ones, questioning the shifting focus to other ranges of knowledge which are secondary in his opinion.

The analysis of the public contest exams for teachers in contrast with the legislation ones aims at finding out how some of the features of such a professional were outlined, highlighting the aforementioned exams as being part of the process in the profession's configuration, through the selection and the requirements for the teaching practice.

In this section one will find an analysis of the exams which were used in some contests dating from two periods in the 19th century (beginning and middle), serving as an illustration of the contents required in written and oral exams and an evidence of what was expected from primary and secondary school teachers as far as Mathematics contents were concerned.

Here the 1803's exams for primary teaching and some others which occurred from the 1850s to the 1870s for both primary and secondary teaching stand out. Reference will be made to the contents of the following exams: *Weights and Measures* and *Arithmetic* (for

primary teaching), and *Algebra, Geometry, Arithmetic and Trigonometry* (for secondary teaching).

From the analysis of the exams applied in 1803 for primary teaching there is a sample of the rubric of the questions related to the Mathematics required contents. The questions were dictated and copied by the candidates. The Mathematics evaluation for the teaching candidate of First Letters consisted in a single Arithmetic question. In the exams which were found, the Arithmetic question consists in a problem whose solution can be reached through a single division of natural numbers (with or without remainder) and displays a rubric which is generally based on the following situation: “*I was given a sum of (specified currency) in order to divide among some (determined quantity) fellows*”. The sum (dividend) is a natural number of six or seven digits, while the divisor is a number which varies between three and four digits. It is thought that division is chosen in order to assess the future teacher’s knowledge due to the fact that it is considered to be the most difficult elementary operation.

At this time public education was restricted to teaching “reading, writing and counting”, where “counting” was supposed to cover Arithmetic rudiments, in other words, the four elementary operations. Therefore, contents related to Geometry were absent. To sum up, the analysis of the documents which were found show that the teacher’s abilities and range of knowledge were also restricted to the aforementioned ones. Thus, what was expected from the teacher was basically what they were going to teach, no more than that. There cannot be found any references of possible manuals which could have guided teachers as for either the contents to be studied or the exam topics.

From the second half of the 19th century on contests become more elaborate. The documentation found reveals that most exams for both primary and secondary schools consisted in dissertational bases (that is, a topic would be drawn and the candidate should give their considerations of it). Such topics, elaborated by the commission organizing the examinations, in other words, the *General Inspector* (or an authority sent by him) and two more teachers, were drawn and should be addressed by the candidates within a set time. The candidates copied the topic which was dictated and wrote about it.

As for the primary teaching subjects, especially Arithmetic, questions hardly ever demanded problem solving or calculation. Most evaluations, as it has been said before, consisted in dissertational exams which aimed at assessing how much the candidate knew about the subject. “Applications” or “practical knowledge” of the subject were highly-considered; however, giving numerical examples of formulae usage did not consist in true applications.

Besides written exams the candidate also sat an oral exam in which they were asked about the same topic as in the written one or not. Thus, the candidate would be able to “correct” the mistakes made in the written exam and be licensed for their performance in the oral exam. From such exams there is no accurate information but some observations made in the proceedings of the examinations. The oral exams could be either overrated in relation to the written ones or regarded as a resource in order to decide the candidates’ classification.

Examples of the required topics in the *Arithmetic* exams for primary school teachers can be observed in the examinations from the 1850s to the 1870s:

- Multiplication of whole numbers. Multiplication and its properties;
- Prime numbers and greatest common divisor;
- Application of the division of whole numbers and its properties;
- Decimal fractions. Operations on decimal fractions;
- Division of whole numbers and decimals;
- Simple and mixed periodical decimal fractions. Converting a decimal into an ordinary fraction.

The *Weights and Measures* exam was also dissertational and included some problems or topics for further explanation besides one or more items. Questions covered knowledge of the Brazilian currencies, time and length measurements. Some example questions are:

- What is the division of gold coins in Brazil and their values?
- Which units are used for length measurement?
- How is time divided? (In other words, centuries, years?)
- Origin of the decimal metric system. Nomenclature of its units. Their multiples and submultiples;
- How much is $\frac{2}{5}$ of 5 arrobas (1 arroba weighs approximately 15kg)? How many minutes are there in $3\frac{3}{4}$ years?

For secondary school teaching, as previously mentioned, exams required contents of *Algebra, Geometry, Trigonometry and Arithmetic*.

In the contest from 1st October, 1856, here follow the topics which were drawn:

- **Arithmetic**

Progressions by difference and their main properties;

Progressions by quotient and their main properties;

Logarithms; Application of the theory of logarithms;

- **Algebra**

Quadratic equations; Conversion of quadratic equations to a single variable;

Relationship between coefficients and roots from the complete quadratic equation; Imaginary values;

- **Geometry**

Convex polygons; Decomposition of polygons into triangles;

- **Trigonometry**

Trigonometrical formulae; Relationship between the trigonometrical lines in a given arc;

An even more accurate list of topics was found in the Arquivo Geral da Cidade do Rio de Janeiro (General Archive of the City of Rio de Janeiro). This list exemplifies the contents which the secondary school teaching candidates were expected to face in the written and oral exams. Despite the fact that the Colégio Pedro II 's (Pedro II High School) program underwent modifications in the 1850s, 1860s and 1870s, it can be said that the level of difficulty of the examinations is basically the same during this period.

Exam topics

Algebra

Squared algebraic quantities and their roots.

E.g.: square root of the trinomial $24a^2b^3c + 16a^4c^2 + 9b^6$.

Demonstration of the general formula for square roots. E.g.: finding via the aforementioned formula a number which added 15 to its square can yield eight times the same number.

Arithmetic

Theory of squared numbers and their roots. E.g.: finding the root of a number with 9 digits.

Theory of calculation of complex numbers. E.g.: addition, subtraction, multiplication and division.

Theory of proportionalities; Rules of three;

Theory of ordinary fractions; conversion of a fraction to its simplest expression; greatest common divisor. E.g.: addition, subtraction, multiplication and division of any fractions;

Theory of decimal fractions. E.g.: addition, subtraction, multiplication and division of any decimal fractions;

Geometry and Trigonometry

The area of a triangle is as proportional to the area of the whole sphere as the difference between the sum of the three angles between opposite faces formed by the planes of the circles which compose those triangles and two right angles is to eight right angles.

The areas of the two spheres are just like the squares of their radiuses or diameters; and their volumes are just like the cubes of these lines.

The square built over the hypotenuse of a right triangle is equal to the sum of the squares built over each one of the other two sides.

Demonstration of the trigonometric identities: $\text{sen}(a+b) = \frac{\text{sen } a \cos b \pm \text{sen } b \cos a}{R^2}$

$$\text{tang}(a \pm b) = \frac{R^2(\text{tan } g a \pm \text{tan } g b)}{R^2 \pm \text{tan } g a \text{ tan } g b}$$

$$\text{sen } a = \frac{R \text{ tan } g a}{\sqrt{R^2 + \text{tan } g a^2}}$$

$$\cos a = \frac{R^2}{\sqrt{R^2 + \text{tan } g a^2}}$$

As mentioned above, the contents required in the teaching selection at this time were the same which featured in the student program. Many of the listed ones still belong to the table of contents which are taught nowadays.

Exam evaluation was not necessarily made by making use of numbers but adjectives, such as “good”, “bad”, “weak”, “insufficient”.

3 Final considerations

The teaching of Mathematics and the process of teacher education in Brazil have undergone several changes since the 19th century. The current mandatory *ensino fundamental* (primary and secondary schools) in Brazil consists in 9 years (for children aged 6 to 14) followed by three more years which compose *ensino médio* (high school, for 15 to 17-year-olds), which provides with access to universities, whether having a vocational scope or not.

In order to teach in the first segment of *ensino fundamental* (from 1st to 5th grade) having a university degree is not necessary; a high school diploma from the *Escolas Normais* is enough. For teachers of the higher grades tertiary education is required.

In the course of their education all teachers study subjects which cover the knowledge of pedagogic theories, teaching legislation, evaluation, psychology of learning, among others. As mentioned before, those contents were absent in the evaluations from contests for teachers of primary and secondary instruction in the 19th century.

Despite having characteristics and functions which were different from those belonging to the Empire, public teaching contests have prevailed so far. This constituent element of the profession ended up imposing itself and represents an important instrument of access to positions in several levels of teaching.

Nowadays, the candidate's approval in many contests is conditioned to other factors than just the written Mathematics exam. The didactics exam (or class exam), teaching experience, institutional education and degree validation become important elements which seek to select a more qualified teacher in order to value not only institutional education but also practical training.

Even though the Mathematics contents keep on being the main aspect of evaluation of teachers, some contests display questions on *Parâmetros Curriculares Nacionais de Matemática* (document from 1996 which enforces norms related to the teaching of Mathematics in all levels and make considerations on the importance of teaching contents, problem solving, history of Mathematics, the use of calculators, mental calculation, among others) besides covering either knowledge of theoretical and methodological bases of education or general educational politics, even if we take into account that these topics appear in a smaller number of questions. Generally speaking, those are multiple-choice exams in contrast with what happened in the 19th century when such a type of questions did not exist.

Some other contests go beyond the Mathematics contents which teachers are supposed to teach by requiring from the candidates more advanced contents such as Linear Algebra and Calculus.

Anyway, teaching education and other issues related to teacher training are still widely debated nowadays, which demands from the professionals of education continuous improvement and search for ways of bettering their qualifications and working conditions, and, last but not least, the process of selection of Mathematics teachers in the country.

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