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Comparison between brazilian education and that of countries with good results in the PISA exam: A study based on TALIS

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ABSTRACT
Brazil has obtained poor results in basic education compared to other countries, especially developed ones. One of the most important actors in the education process are the teachers. The Teaching and learning international survey (TALIS), coordinated by the Organization for Economic Cooperation and Development (OECD), provides relevant information about the learning environment and working conditions of basic education professionals. This article proposes a study on TALIS, comparing Brazilian basic education with that of well-ranked countries in the examination of the Program for International Student Assessment (PISA) and verifying how adjusted Brazilian basic education is to the best international practices. The Apriori algorithm was used to mine the rules of association, allowing the investigation of which factors are associated with the improvement of education in high school institutions in the perception of the teaching public.

Keywords: TALIS, PISA, Data Mining, Education, Machine, Learning.

1 INTRODUCTION

The National Institute of Educational Studies and Research Anísio Teixeira (INEP), a Brazilian government institution, makes available on its portal several types of microdata that are collected in research, evaluations and examinations, which can involve both basic and higher education. The TALIS (Teaching and Learning International Survey) encompasses one of these microdata and consists of "an international survey coordinated by the Organization for Economic Cooperation and Development (OECD) focusing on the learning environment and working conditions of basic education professionals" [2].

The most recent TALIS data released on the INEP portal refer to the international report of the year 2018, having as target audience of the research directors and teachers of elementary and secondary education (Brasil, 2020). The microdata bring information, such as: qualification of those involved in

the research, working conditions, professional development, teaching offered, aspects related to student diversity, school climate and job satisfaction, school leadership, etc.

Among the different stages of an individual's educational formation, from literacy to graduate school, there is no doubt that basic education is of great relevance for the intellectual development of the student, providing the development of skills that will allow their rapid insertion in the labor market or underpinning the verticalization of their studies. In a broader context, basic level education is fundamental for the development of a country, because if it is deficient, undergraduate and graduate programs will also be harmed, leading to a gap in technical and scientific labor.

The purpose of this article is to conduct a study of the microdata of TALIS in its most recent publication (until the date of submission of this article, the most recent publication corresponds to the year 2018), evaluating the aspects related to quality teaching in Brazilian education and comparing them with countries well ranked in the examination of the Program for International Student Assessment (PISA). The study will be conducted using data from Brazil, Canada, Sweden and Chinese Taipei. It seeks to answer the following questions: What are the educational practices adopted in countries that are reference in the PISA exam? Are schools with better performance in Brazilian basic education in compliance with the educational practices adopted in countries with good PISA exam scores? To conduct this study will be used data mining techniques through the *Apriori algorithm*.

The general objective of this work is to identify the best international practices adopted by teachers of basic education and to verify how adequate Brazilian education is to this reality. Based on the results obtained in the research involving Brazilian educational institutions in comparison with foreign institutions from 3 countries well ranked in the PISA exam, some measures are proposed in order to improve Brazilian basic education at the secondary level.

This article is organized as follows: Theoretical foundation section; Methodology section used in the research; Section of Studies carried out; Conclusions section where the definitions obtained throughout the study are displayed.

2 THEORETICAL FOUNDATION

This Section is divided into two subsections: the PISA subsection discusses the PISA exam and its relevance as an indicator of quality in the context of basic education; The TALIS subsection discusses the structure of the TALIS questionnaire and the studies related to the topic. Next, the Association Rules Mining subsection introduces the technique of mining association rule data via the *Apriori algorithm*.

3 PISA

The Programme for International Student Assessment (PISA) is a study conducted by the OECD with adolescents aged 15 years that makes it possible to measure the performance of students in several countries in three domains of knowledge: Mathematics, Science and Reading. [16]

In Brazil, since 2000 when it was the first edition of PISA, the body responsible for directing this study is INEP. Since then the country has always participated as a guest, being considered a potential member country by the organization [16].

In general, Brazil obtained in this exam scores below the average of the OECD member countries, but, since the PISA result was considered a reference in the guidance of policies in the area of education, in the 2012 edition "Brazil had the third largest evolution in the overall performance of the program until 2009" [16], being the country with the greatest absolute advance in proficiency in mathematics taking into account previous editions. Since then the country has remained stagnant with the grades without showing a great evolution [16].

PISA exam results are divided into levels ranging from 1 (worst performance) to 6 (best performance). In the last result released for this exam (2018), Brazil had only 2% of students in the reading category reaching the maximum level predicted by the OECD, while 50% of students reached at least level 2 of reading proficiency (OECD average for this same classification range was 77%). In mathematics the result was even worse: only 1% of the students had the best performance (levels between 5 and 6). For comparison, China had 44% of its students reach the highest performing levels in mathematics. Chinese Taipei, the country covered in this study (as will be highlighted in the Section of Studies Carried Out), had 23% of students reaching the highest levels of performance in mathematics. In the area of Science, 45% of the Brazilian students assessed reached level 2 or higher (against an OECD average of 78%), while only 1% of students performed better (against an OECD average of 7%).

However, Brazilian schools in the private and federal spheres exceed the national average and are above the OECD average [10]. In a study done and made available by the MEC portal related to the Program for International Student Assessment (PISA) involving 597 schools (MEC, 2019), the proficiency of education in Brazil in Reading, Mathematics and Science was verified. Despite the increase in investments made by the Brazilian government in public schools, private schools came out ahead in the 3 categories measured: Reading - score of 510, while OECD member countries had 487 average and national average was 413; Mathematics – score of 473 while OECD member countries averaged 489 and the national average was 384; Science – score of 495 while OECD member countries averaged 489 and the national average was 404 [10]. Due to the satisfactory results in PISA, Brazilian private schools were selected to be studied in order to understand which factors are associated with the

improvement of the quality of education in the perception of the teachers of this institution. Details about this study can be found in the Studies Conducted Section.

4 TALIS

TALIS, as already described in the Introduction Section, collects data on the educational environment and working conditions in elementary and secondary schools, consisting of two questionnaires that are applied together with the PISA exam: one for the teacher and the other for the director [5]. Evaluations of this type, made on a large scale, make clear the precarious situation of many schools, especially those of the public network, with performance of their students below the expected [5].

TALIS investigated 48 countries during the years 2017 and 2018 evaluating the teaching and learning environment in elementary and secondary schools, verifying the perception of teachers and principals [3]. In 2009 there was the first round of the TALIS survey, with 24 countries participating, including Brazil [3]. In 2014 there was a second round, with 34 countries where Brazil again participated [3]. In its third round (most recent research conducted in the years 2017 and 2018) TALIS addresses new aspects, such as the theme of teaching in environments with diversity [3].

Some perceptions about education in Brazil were revealed by the national report of the international survey on teaching and learning - Talis 2018 (Brasil, 2019), such as:

- 97% of Brazilian teachers in the final years of elementary school stated that they are prepared to teach the content of some or all of the subjects included in their initial or complementary training, and the same perception was verified among 97% of high school teachers;
- According to elementary school teachers, the sectors that require the most investment in education are: high-quality professional development for teachers (95%), salary increase (93%) and support for students with special needs (88%). When high school teachers were questioned on the same subject, the following percentages were reached: high-quality professional development for teachers (93%), salary increase (93%) and support for students with special needs (83%).

The following table presents a compilation of some authors who studied the TALIS data and the respective techniques employed in the study.

Table 1. TALIS Studies

Author	What you studied	Techniques used
Batista (2015)	It analyzed the styles of school leadership in basic education in Brazil and Spain according to the TALIS survey, verifying that in Brazil, the instructional school leadership style has predominated and, in Spain, the administrative school leadership style	Analysis of the TALIS report (year 2009)
Brasil (2019)	It describes the application of the TALIS survey by INEP in Brazil and brings analyses to the sample of Brazilian teachers and directors used in the research.	Descriptive statistics
Capistrano e Cirotto, (2014)	It analyzed the degree of job satisfaction reported by Brazilian elementary school teachers	Descriptive statistics
Corradini (2012)	It analyzed possible justifications for the results verified in PISA (Program for International Student Assessment) and in the TALIS survey, considering the configuration of well-evaluated schools and their institutional practices	Interviews, questionnaires, survey of PISA and TALIS results using descriptive statistics
Trojan e Landini (2013)	It evaluated some aspects related to the working conditions offered by schools to teachers in Brazil and Spain.	Analysis of the TALIS report (year 2009)
Trojan e Sipraki (2015)	It analyzed the use of the Likert Scale in the TALIS survey. Problems were identified in the formulation of the applied questions and in the analyses present in the report, which hinder the evaluation of the themes investigated in the TALIS research.	Likert Scale
Zukowski-Tavares,	It discussed the profile of the basic education teacher of a	Descriptive and inferential statistics

Fernandes e Luz (2017)	confessional teaching network in interface with national and international reports, concluding that the joint accountability of educational results is essential in the continuous commitment to the construction of plural and citizen curricula together with the support for the professionalization and valorization of the teaching career.	

It is noteworthy that Table 1 presented does not exhaust the theme related to the study of TALIS. It should also be noted that, until the date of submission of this article, no studies were found with the microdata of TALIS of 2018 (the most recent published) that discussed the Brazilian reality. For the 2018 TALIS, only studies mentioning foreign countries were located. These studies were omitted from this article.

5 MEMBERSHIP RULES MINING

The *Apriori* algorithm will be used in this work to mine the association rules. It seeks to discover important associations between the factors that lead to better or worse education in Brazil regarding the data present in the questionnaire completed by the teachers.

According to Romão et al. [12] "One of the most attractive techniques is the Mining of Association Rules, which has as a highlight the *Apriori* algorithm. It can work with a large number of attributes, generating several combinatorial alternatives between them."

According to Hoed [8], the mining of association rules has many commercial applications, for example, in supermarkets, when one can analyze, from a database, the correlation between the sale of different products. The discovery of rules of association of this type can help in decisions such as: To arrange the goods in the best way in the supermarket, strategically placing the correlated products next to each other. "The goal, then, is to find all the relevant rules of association between the items, of type X(antecedent) ⇒ Y(consequential)" [12]. According to Hoed [8], association rule mining is not only useful in business transaction contexts, but can be employed in other cases such as large educational databases. With regard to the problem studied in this article, it will be verified, in the Section of Studies Carried out, the factors related to the improvement of education in high schools, according to the perception of teachers of this modality.

The discovery of association rules can be broken down into two steps, according to Agrawal [12]: locate the sets of items (itemsets) that are supported above the defined minimum; Use the itemsets

obtained in step 1 to generate the database membership rules. Some important definitions about association rule mining: "To every association rule A → B we associate a degree of confidence, determined by conf (A → B)" [6]. The degree of confidence would be the probability that a transaction that has one item also contains the other item. The following Equation 1 formalizes this definition [6]:

$$conf(A \rightarrow B) = \frac{number\ of\ transactions\ that\ support\ (A \cup B)}{number\ of\ transactions\ that\ support\ A} \quad (1)$$

According to Ribeiro [11], to find rules considered strong, in addition to support and trust, the lift measure is also used, which is defined by Equation 2:

$$lift(A,B) = \frac{P(A \cup B)}{P(A)P(B)} \quad (2)$$

Also according to Ribeiro [11], "The occurrence of an item A is independent of an item B if P(A U B) = P(A)P(B). If not, there is a correlation between the items." Thus, if the value of Equation 2 is less than 1, then the occurrence of A correlates negatively with the occurrence of B. If the result is greater than 1, A and B correlate positively, evidencing that the occurrence of A implies the occurrence of B. As will be detailed in the Methodology Section, within the scope of this study, Only the rules obtained whose *lift* is greater than 3, indicating a positive correlation between the right and left part of the rule, will be considered as valid.

The execution phases of the *Apriori algorithm* comprise generation, pruning and validation [6]. Briefly, without going into too much detail, in the generation phase the itemsets that have some chance of being frequent are generated. In the pruning phase, the itemsets are discarded without chances of being frequent and in the last phase the support of each of the itemsets of the set is calculated [6]. The operation of the *Apriori* algorithm is described as follows:

> In the first passage, the support for each individual item (sets-of-1-item) is counted and all those that satisfy the suporte_mínimo are selected, constituting the frequent sets-of-1-item (F1).
> In the second iteration, candidate sets-of-2-items are generated by joining the 1-item sets (the joining is done through the *Apriori-gen* function) and their supports are determined by searching the database, thus finding the frequent 2-item sets. The *Apriori* algorithm proceeds iteratively, until the set-of-k-items found is an empty set. [7].

6 METHODOLOGY

In this work we used the technique of mining rules of association through the *Apriori* algorithm and used the methodology of data mining Cross Industry Standard Process for Data Mining (CRISP-

DM) which comprises the following steps: business understanding, data understanding, data preparation, modeling (application of data mining techniques), evaluation of results and development.

In the stage of understanding the business, studies were made to understand the objectives of the research as described in the Introduction Section of this work.

In the stage of understanding the data, the analysis of the TALIS microdata applied to Brazil available on the INEP Portal (https://dados.gov.br/dataset/inep-microdados-da-pesq-inter-ensino-e-aprendizagem-talis) was made, being verified which categories and variables are important for the study with the use of the Microsoft Excel spreadsheet software. The same procedure was conducted for the countries chosen in this research: Canada, Sweden and Chinese Taipei. Talis microdata for these countries can be found on the OECD portal [21]. Canada, Sweden and Chinese Taipei are, respectively, in the following PISA exam placements in the Reading category: Canada – 6th, Sweden – 11th, Chinese Taipei – 17th; Mathematics: Canada - 11th, Sweden - 16th, Chinese Taipei - 4th; Sciences: Canada - 8th, Sweden - 19th, Chinese Taipei - 10th. The reason that countries that are not in the top 3 places of PISA were chosen to integrate this study, is due to the fact that the TALIS microdata studied correspond to high school, and, as explained in the PISA subsection of this article, this exam is not mandatory at the secondary level and therefore was not conducted for this modality of basic education in all countries, but only in a few.

It is worth mentioning that the microdata are arranged and divided into eight different categories and for this study the following categories were used: Basic information and qualification; Current work; Professional development; Teaching in general; School climate and job satisfaction and derived variables/scale variables. Excel was used in this step, because most of the data analyzed are in Comma Separated Values (CSV) format. The microdata corresponding to the year 2018 were used. In the case of Brazil, the study was conducted by filtering the schools of the private sphere, because the intention is to verify the factors related to quality education and these institutions are the best ranked in PISA as mentioned in the subsection "PISA" of this article. Several variables were considered in this study using the microdata of the general and specific questions applied to Brazilian, Canadian, Swedish and Chinese high school teachers, such as:

- TT3G03: Highest level of formal education completed
- TT3G11B: Years of experience working as a teacher
- TCHAGEGR: Age group
- TT3G53J: Job satisfaction level
- TT3G54A: Level of satisfaction with salary
- TT3G62D_BRAX23: Opinion about education in school whether it is improving or not (this variable is present only in TALIS corresponding to Brazil)

- Among other 20 variables of the questionnaire that involve factors such as professional development, school climate, teaching in general, etc.

During data preparation, the databases were cleaned by removing variables that are not important for the study. The Excel software was used in this process. Some variables were discretized to facilitate data analysis: TT3G11B, TCHAGEGR.

In the discretization of the variable about the years of experience, the mathematical quartiles were used to classify the values. The variable TT3G11B was discretized as follows: between 0 and 9 years of experience: classified as little experience (below the first quartile); Between 9 and 15 years of experience: classified as below average experience (between the first and second quartiles); Between 15 and 22 years of experience: classified as average (between the second and third quartile); Over 22 years: classified as experienced (above the third quartile). The TCHAGEGR variable that defines the age range of teachers was based on the classification used by the United Nations Demographic Yearbook review [9]. Enrollees aged between 15 and 25 years are considered young, between 25 and 59 years are considered adults and those aged 60 years or more are considered elderly.

During the modeling phase, the Apriori *algorithm was used* to verify which variables are associated with higher quality high school education in Brazil, Canada, Sweden and Chinese Taipei, according to the perception of teachers working in this modality. In this step, the software R version 4.2.1 was used.

The rules were filtered considering the following parameters:

- Minimum confidence of 85%
- Minimum support of 0.01
- *Lift* equal to or greater than 3.

In relation to Brazil, rules that do not present the variable TT3G62D_BRAX23 were removed from the study, because it is intended to locate rules associated with the improvement of education in institutions in the perception of teachers, which is precisely what this variable signals. In relation to the other countries, the rules were ranked according to the filters mentioned in the previous paragraph.

During the evaluation phase, the results generated by the *Apriori* algorithm were discussed and analyzed, which will be detailed in the Studies Section of this article.

During the development phase, actions to improve teaching in Brazilian schools are discussed, taking into account the results obtained in the previous phase and comparing the rules found for the countries selected for the study, as will be detailed in the Conclusions Section.

7 STUDIES

The following tables demonstrate the outputs of the R software when applying the *Apriori* algorithm. The rules presented are only a portion of those that were generated by the algorithm. The

10 rules displayed comprise those with the highest value for the *lift* parameter among Brazilian private schools where teachers agree that teaching is improving and for other countries comprises all high schools. As mentioned in the Methodology Section of this article, the choice to work with rules on private schools is due to the fact that they stand out in the last published result of PISA (2018), being close to the OECD average. With this, it is intended to identify factors that favor the good performance of these schools and enable the comparison with the countries studied well ranked in PISA. Here are the meanings of each of the variables used: TT3G62D_BRAX23 = "Overall, I believe that education in my school is improving"; TT3G06C1 = "Have the following components been included in your initial or complementary training? Pedagogy (didactics) in general"; TT3G08 = "Was teaching the first career choice?"; TT3G11B: "Years of experience working as a teacher"; TT3G22D = "Participation in qualification program in the last 12 months"; TT3G23E = "Have any of the following topics listed below been included in your professional development activities during the last 12 months? ICT (Information and Communication Technology) skills for teaching"; TT3G27A = ""; TT3G06H1 = "Have the following components been included in your initial or complementary training? Use of ICT (Information and Communication Technology) for teaching"; TT3G24H = "With respect to the professional development you have participated in in the last 12 months, have you received any of the following supports? Increase in salary"; TT3G27E = "For each of the areas listed below, please indicate to what extent you currently need professional development. ICT (Information and Communication Technology) skills for teaching"; TT3G32A = "Teachers in this school seek to develop new ideas for teaching and learning"; TT3G54A: "Salary satisfaction level"; TT3G53J = "We would like to know how you feel, in general, about your work. To what extent do you agree or disagree with the following statements? Overall, I'm satisfied with my work." TT3G49A = "To what extent do you agree or disagree with the following statements about what happens in this school? Teachers and students generally get along with each other." TT3G03 = "Highest level of formal education completed"; TT3G06C2 = "To what extent do you feel prepared for each component of your teaching? Pedagogy (didactics) in general"; TT3G06H2 = "To what extent do you feel prepared for each component of your teaching? Use of ICT (Information and Communication Technology) for teaching"; TT3G34M = "With respect to your teaching, to what extent are you able to do the following? Support student learning through the use of digital technologies (e.g., computers, tablets, interactive whiteboards)"; TT3G34L = "With respect to your teaching, to what extent are you able to do the following? Vary teaching strategies in my class"; TCHAGEGR = "Age group".

Regarding the columns of the tables, the meaning of each of them follows: **N** – Number of the rule generated on the scale of 1 to 10; **Left item** – Left side with the rule generated by the algorithm; **Right item** – Right side with the rule generated by the algorithm; **Sup** – Support of the generated rule. **Con – Trust of the generated rule and** L **–** Lift *of the generated rule.*

Table 2. Rules of association obtained for schools in Brazil

N	Left Item	Right Item	Sup	Con	*L*
1	{TT3G62D_BRAX23=FOUR}	{TT3G06C1=UM}	0,7	0,91	9,8
2	{TT3G08=UM, TT3G23E=UM}	{TT3G62D_BRAX23=FOUR}	0,25	0,89	3,56
3	{TT3G06H1=UM,TT3G24H=TWO,TT3G27E=TRES}	{TT3G62D_BRAX23=FOUR}	0,25	0,89	3,56
4	{TT3G53J=FOUR}	{TT3G62D_BRAX23=FOUR}	0,2	0,89	3,5
5	{TT3G06C1=UM,TT3G06H1=UM, TT3G27E=THREE,TT3G49A=THREE}	{TT3G62D_BRAX23=FOUR}	0,19	0,91	4,7
6	{TT3G03=FIVE,TT3G06C1=UM, TT3G23E=UM,TT3G27E=TRES}	{TT3G62D_BRAX23=FOUR}	0,15	0,89	5,9
7	{TT3G06C2=TRES,TT3G06H1=UM, TT3G06H2=TRES,TT3G49A=TRES}	{TT3G62D_BRAX23=FOUR}	0,15	0,89	5,9
8	{TT3G34M=TRES,TT3G49A=TRES ,TT3G53J=TRES}	{TT3G62D_BRAX23=FOUR}	0,14	0,88	6,2
9	{TT3G27A=THREE,TT3G34L=THREE, TCHAGEGR=ADULT}	{TT3G62D_BRAX23=FOUR}	0,14	0,88	6,2
10	{TT3G27A=TRES,TT3G34L=TRES, TT3G53J=TRES }	{TT3G62D_BRAX23=FOUR}	0,15	0,88	5,8

It is important to note that all the rules contain the variable TT3G62D_BRAX23 with a value of four, which refers to teachers who agree that education in the school in which they teach is improving. Therefore, the variables in each rule found that are associated with this opinion will be presented below. For better understanding, the following are the comments of the rules obtained: **Rule 1** – 91% of teachers had pedagogy inserted in their training; **Rule 2** – 89% of teachers had teaching as their first career option and studied Information and Communication Technology (ICT) resources in the last 12 months; Rule 3 – 89% of teachers had ICT in training, had no salary increase in the last 12

months and feel moderate need to improve with ICT; **Rule 4** – 89% of teachers are totally satisfied with their work; **Rule 5** – 91% of teachers have had pedagogy and ICT inserted in their training, feel moderate need to improve the use of ICT and teachers and students get along; **Rule 6** – 89% of teachers have as their level of training the graduation, had pedagogy inserted in the training, studied ICT in the last 12 months and feel moderate need to improve with ICT; **Rule 7** – 89% of teachers feel well prepared to deal with pedagogy in general, have had ICT in training, feel well prepared to use ICT and claim that teachers and students get along; **Rule 8** – 88% of teachers are very supportive of their students using technological methods, claim that teachers and students do well and are satisfied with the work; **Rule 9** – 88% of teachers seek to vary the teaching greatly during class, feel moderate need to improve their knowledge in their area of teaching and are adults (age between 25 and 59 years); **Rule 10** – 88% of teachers seek to vary the teaching greatly during class, feel moderate need to improve their knowledge in their area of teaching and are satisfied with the work.

Table 3. Membership rules obtained for schools in Canada

N	Left Item	Right Item	Sup	Con	*L*
1	{TT3G06C1=UM, TT3G23E=TWO,TT3G24H=TWO}	{TT3G22D=TWO}	0,37	0,94	3
2	{TT3G06C1=UM, TT3G24H=TWO,TT3G34M=FOUR}	{TCHAGEGR=ADULT}	0,37	0,94	3
3	{TT3G06C1=UM, TT3G06H1=UM,TT3G08=UM,TT3G22D=TWO,TCHAGEGR=ADULT}	{TT3G24H=TWO}	0,39	0,98	3
4	{TT3G06C1=UM, TT3G06H1=UM,TT3G08=UM,TT3G22D=TWO,TCHAGEGR=ADULT}	{TT3G03=FIVE}	0,34	0,86	3
5	{TT3G03=FIVE,TT3G06C2=TRES,TT3G24H=TWO}	{TT3G22D=TWO}	0,37	0,93	3
6	{TT3G23E=TWO, TCHAGEGR=ADULT}	{TT3G22D=TWO}	0,37	0,94	3
7	{TT3G06C1=UM, TT3G24H=TWO,TT3G34L=TRES}	{TT3G22D=TWO}	0,37	0,94	3
8	{TT3G06H1=UM, TT3G08=UM,TT3G22D=TWO,TT3G24H=TWO,TCHAGEGR=ADULT}	{TT3G03=FIVE}	0,33	0,85	3
9	{TT3G06H1=UM, TT3G24H=TWO,TT3G53J=TRES,TCHAGEGR=ADULT}	{TT3G06C1=UM}	0,39	0,99	3
10	{TT3G03=FIVE,TT3G06C1=UM,TT	{TT3G22D=TWO}	0,36	0,93	3

	3G06C2=TRES,TT 3G24H=TWO}				

Here are the comments for the rules obtained in Table 3: **Rule 1** – 94% of the teachers who had didactic pedagogy in general in the training process, did not seek professional development during the last 12 months in relation to ICT, did not have a salary increase, also did not participate in any qualification program in the last 12 months; **Rule 2** – 94% of teachers who had didactic pedagogy in general in the training process, did not have a salary increase, are very supportive of student learning through technological means, are also adults; Rule 3 – 98% of teachers who had didactic pedagogy in general in the training process, had use of ICT in the training process, teaching was the first career option, did not participate in any qualification program in the last 12 months, are adults, also had no salary increase; **Rule 4** – 86% of teachers who had didactic pedagogy in general in the training process, had use of ICT in the training process, teaching was the first career option, did not participate in any qualification program in the last 12 months, are adults, also completed Higher Education; **Rule 5** - 93% of teachers who have completed Higher Education, feel well prepared to deal with pedagogy, had no salary increase, also did not participate in any qualification program in the last 12 months; **Rule 6** – 94% of teachers who have not sought professional development during the last 12 months in relation to ICT and who are adults, also did not participate in any qualification program in the last 12 months; **Rule 7** – 94% of teachers who had didactic pedagogy in general in the training process, did not have a salary increase and who seek to vary their teaching strategies greatly, also did not participate in any qualification program in the last 12 months; **Rule 8** – 85% of teachers who had use of ICT in the training process, in which teaching was the first career option, did not participate in any qualification program in the last 12 months, had no salary increase and who are adults, also completed Higher Education; **Rule 9** – 99% of teachers who had use of ICT in the training process, had no salary increase, are satisfied with the work and who are adults, also had didactic pedagogy in general in the training process; **Rule 10** – 93% of teachers who completed Higher Education, had didactic pedagogy in general in the training process, feel well prepared to deal with pedagogy, had no salary increase, also did not participate in any qualification program in the last 12 months.

Table 4. Rules of association obtained for schools in Sweden

N	Left Item	Right Item	Sup	Con	*L*
1	{TT3G03=SIX,TT3G08=UM}	{TT3G22D=TWO}	0,39	0,98	3
2	{TT3G03=SIX,TT3G08=UM}	{TT3G24H=TWO}	0,37	0,95	3
3	{TT3G03=SIX,TT3G08=UM}	{TT3G06C1=UM}	0,39	0,99	3
4	{TT3G03=SIX,TT3G08=UM,TCHAGEGR=ADULT}	{TT3G24H=TWO}	0,37	0,95	3
5	{TT3G03=SIX,TT3G08=UM,TCHAGEGR=ADULT}	{TT3G06C1=UM}	0,39	0,99	3
6	{TT3G03=SIX,TT3G23E=UM}	{TT3G06C1=UM}	0,39	0,98	3
7	{TT3G06H1=UM,TT3G24H=TWO,TCHAGEGR=ADULT}	{TT3G06C1=UM}	0,38	0,96	3
8	{TT3G03=SIX,TT3G23E=UM}	{TT3G22D=TWO}	0,39	0,98	3
9	{TT3G03=SIX,TT3G08=UM,TCHAGEGR=ADULT}	{TT3G22D=TWO}	0,39	0,98	3
10	{TT3G03=SIX,TT3G23E=UM,TCHAGEGR=ADULT}	{TT3G22D=TWO}	0,39	0,98	3

Here are the comments for the rules obtained in Table 4: **Rule 1** – 98% of the professors who are in the doctoral process and teaching was the first career option also did not participate in any qualification program in the last 12 months; **Rule 2** - 95% of the professors who are in the doctoral process and teaching was the first career option, also had no salary increase; **Rule 3** - 99% of the professors who are in the doctoral process and teaching was the first career option, also had didactic pedagogy in general in the training process; **Rule 4** - 95% of teachers who are in the doctoral process, teaching was the first career option and are adults, also had didactic pedagogy in general in the training process; **Rule 5** - 99% of the professors who are in the doctoral process, teaching was the first career option and are Adults, also had didactic pedagogy in general in the training process; **Rule 6** - 96% of the teachers who had use of ICT in the training process, who did not have a salary increase and who are adults, also had didactic pedagogy in general in the training process; **Rule 7** - 98% of professors who are in the doctoral process and sought professional development during the last 12 months in relation to ICT, also did not participate in any qualification program in the last 12 months; **Rule 8** - 98% of professors who are in the doctoral process and who have sought professional development during the last 12 months in relation to ICT, also did not participate in any qualification program in the last 12 months; **Rule 9** - 98% of teachers who are in the doctoral process, teaching was the first career

option and who are adults, also did not participate in any qualification program in the last 12 months; **Rule 10** - 98% of professors who are in the doctoral process, have not had a salary increase and who are adults, also did not participate in any qualification program in the last 12 months.

Table 5. Rules of Association obtained for Chinese Taipei schools

N	Left Item	Right Item	Sup	Con	*L*
1	{TT3G03=SIX,TT3G06H1=UM}	{TT3G06C1=UM}	0,39	0,97	3
2	{TT3G03=SIX,TT3G06H1=UM}	{TCHAGEGR=ADULT}	0,39	0,98	3
3	{TT3G22D=TWO,TT3G24H=TWO,TT3G32A=TRES,TT3G49A=TRES}	{TT3G06C1=UM}	0,38	0,96	3
4	{TT3G22D=TWO,TT3G24H=TWO,TT3G32A=TRES,TT3G49A=TRES}	{TCHAGEGR=ADULT}	0,38	0,95	3
5	{TT3G06C2=TRES,TT3G22D=TWO,TT3G24H=TWO,TCHAGEGR=ADULT}	{TT3G06C1=UM}	0,39	0,98	3
6	{TT3G06C1=UM,TT3G24H=DOIS,TT3G49A=THREE,TT3G53J=THREE,TT3G54A=THREE}	{TT3G22D=TWO}	0,34	0,85	3
7	{TT3G08=UM,TT3G24H=DOIS,TT3G32A=THREE,TT3G49A=THREE}	{TCHAGEGR=ADULT}	0,38	0,96	3
8	{TT3G08=UM,TT3G24H=DOIS,TT3G32A=THREE,TT3G49A=THREE}	{TT3G06C1=UM}	0,38	0,97	3
9	{TT3G06C1=UM,TT3G06H1=UM,TT3G24H=TWO,TT3G49A=TRES}	{TCHAGEGR=ADULT}	0,38	0,97	3
10	{TT3G06C1=UM,TT3G06C2=THREE,T	{TCHAGEGR=ADULT}	0,38	0,95	3

	T3G24H=DOIS,TT3G49A=THREE}				

Here are the comments for the rules obtained in Table 5: **Rule 1** - 97% of the teachers who are in the doctoral process and who had use of ICT in the training process, also had didactic pedagogy in general in the training process; **Rule 2** - 98% of the professors who are in the doctoral process and who had use of ICT in the training process, are also Adults; **Rule 3** - 96% of teachers who did not participate in any qualification program in the last 12 months, who did not have a salary increase, who stated that most teachers in this school seek to develop new ideas for teaching and learning, who stated that teachers and students get along, also had didactic pedagogy in general in the training process; **Rule 4** - 95% of teachers who have not participated in any qualification program in the last 12 months, who have not had a salary increase, who stated that most teachers in this school seek to develop new ideas for teaching and learning, who stated that teachers and students get along, are also adults; **Rule 5** - 98% of teachers who feel well prepared to deal with pedagogy, did not participate in any qualification program in the last 12 months, had no salary increase and who are adults, also had didactic pedagogy in general in the training process; **Rule 6** - 85% of the teachers who had didactic pedagogy in general in the training process, who stated that teachers and students do well, who are satisfied with the work and satisfied with the salary, also did not participate in any qualification program in the last 12 months; **Rule 7** - 96% of teachers who had teaching as their first career option, who stated that teachers and students get along, who stated that most teachers in this school seek to develop new ideas for teaching and learning and who are satisfied with the work, are also Adults; **Rule 8** - 97% of teachers who had teaching as the first career option, who stated that teachers and students get along, who stated that most teachers in this school seek to develop new ideas for teaching and learning and who are satisfied with the work, also had didactic pedagogy in general in the training process; **Rule 9** - 97% of teachers who had didactic pedagogy in general in the training process, had use of ICT in the training process, who stated that teachers and students get along well and are satisfied with the work, are also Adults; **Rule 10** - 95% of teachers who had didactic pedagogy in general in the training process, feel well prepared to deal with pedagogy and stated that teachers and students get along, they are also adults.

In general, the rules shown in Tables 3, 4 and 5 indicate the following reality for a good portion of the teachers who work in basic education in Canada, Sweden and Chinese Taipei: adequate pedagogical teacher training (including having a doctorate as training, a situation that is different from the reality of most Brazilian basic education teachers), appropriate use of ICTs and teaching methodologies, where teachers feel prepared for the exercise of the profession and satisfied with their work.

8 CONCLUSIONS

The reference work demonstrates the factors that are linked to quality education in Brazil, Canada, Sweden and Chinese Taipei.

As I commented in the previous section, several rules have been generated. In the tables of the section "Studies Performed" were presented only the 10 rules with the highest *lift* for each country evaluated. However, it can be verified that, among the rules that were not selected by this filter, several cite Brazilian teachers dissatisfied mainly with salary and who claim that professional development is expensive. Having this statement among the rules, it is possible to identify that the remuneration of teachers in Brazil is not at all flashy for recent graduates and, for those who wish to pursue a career, professional development is not consistent with the salary they receive.

It is worth highlighting here other factors not elucidated in the rules of the previous section and that also contribute to quality education in foreign countries. A common factor among Canada, Sweden and Chinese Taipei is the ability of each province/municipality to provide an equal education structure for all students regardless of their socioeconomic class. Of course, there are also the specifics of teaching in these countries. Chinese Taipei, for example, follows a stricter and more disciplined line in its school base compared to the other two countries mentioned. Another factor in common among these 3 countries is the salary floor for teachers: converting the amounts into dollars, the monthly amount for Canada, Sweden and Taipei are respectively: US$ 9,000.00; $5,000 and $8,000. On the other hand, in Brazil, teachers receive an average of US$ 650 (Quotation 09/25/22) [17].

Clearly the salary floor in Brazilian education is discrepant compared to other countries. There are well-ranked countries in PISA where the salary floor for teachers is equivalent, for example, to the banking profession which is well paid in many countries. An example is one of the countries being studied: Chinese Taipei, which seeks the equivalence of a good remuneration for teachers [20]. In addition, the teaching profession is seen as the basis for the general improvement of these countries. No wonder, it is very judicious to choose teachers for each institution.

Another factor that influences this disparity in remuneration are the privileges for certain classes of Brazilian public servants, such as those linked to the legislative and judicial branches. There are similar services within the Brazilian public sphere, but depending on the position of the server the salary difference can be up to 7 times greater if we compare, for example, an ambulance driver with a senator or deputy driver. A solution to this discrepancy would be to establish a parity between the wages paid in the country, in addition to extinguishing any monetary privilege that makes this disparity possible. This would include far-reaching legislative and political reforms, including even constitutional reform [22].

In the latest report released by PISA (year 2018), China led the ranking followed by Singapore [25]. Something to highlight in the educational practices of these countries is the issue of content in

Chinese schools, as well as cultural rigidity (as in Chinese Taipei mentioned earlier in this section). In everyday life classes are usually short lasting up to 35 minutes, where teachers teach only a single type of concept at a time and since primary school students have English and mathematics classes [26]. On the other hand, classes in Brazil last between 50 minutes and an hour in most elementary and middle school institutions. In Singapore they adopt a policy in which it is not enough for the student to learn how to solve problems, but how the whole process of solving works. In these countries, having the teaching profession is something respectful and desired. In addition, in Singapore, teachers have the incentive to specialize, because as it is a desired area the competition is also great. Another important factor is the massive use of technological means made available by the educational institution for student learning (ICTs). There is also concern about students' psychological issues that are treated as something serious within education and when preparing for professional competition [27].

The Brazilian schools in their great majority compared to the top 3 countries of PISA completely escape from the educational reality implemented in these countries, taking into account all the institutions (public and private) the policies adopted in Brazil do not understand the practices of the reference countries, although most of the teachers have the pedagogy implemented in their training, There are no incentives as in these countries that enable a narrative where competition is equal in all school categories, so federal and private schools, as already mentioned, are ahead of most other Brazilian schools, because the policies adopted are closer to the reference countries, be it competitiveness, above average salary, possibility of using ICTs etc.

Brazil suffers from structural political changes with each mandate, interfering in every important base for society, such as education, health, transportation, etc. It should also be considered that Brazil, being a country with a vast territory, has more difficulties in managing its education than territorially smaller countries, since there is a diverse cultural and also very large income distribution among the different Brazilian regions. To deal with this geographical factor, Brazil can take the example of Canada, which allows provinces to adopt the best methodology, taking into account their specificities. Greater decentralization of power, giving greater autonomy to Brazilian municipalities is, therefore, something to be studied and considered. Regarding investment, a good example would be Sweden, which invests an average of US$ 11,400 per student [23], while in Brazil an average of US$ 3,900 is spent[24].

It is clear that the policies adopted in countries whose education has prospered need to be analyzed and evaluated regarding the feasibility of adoption in Brazil. However, this analysis must take into account the Brazilian particularities, since our economic, social and cultural reality differs greatly from the reality of the countries that were the object of this study and other countries that are part of the OECD. With this in mind, it is important to note that, as verified in the section Studies carried out from the rules obtained by *the Apriori* algorithm, countries such as Sweden, Canada and

Chinese Taipei, which are a reference in education, have teachers with good pedagogical training, who attend or have attended a doctorate, teachers have adopted teaching as the first option of work (which shows the attractiveness of the profession in these countries) and had ICTs in the training process. In Brazil, private schools, which presented the best results in PISA among national schools, the rules obtained also point to the use of ICTs in teacher training, for adequate pedagogical training and the use of diversified methodologies and in constant improvement. Thus, there is evidence that some practices adopted in Brazilian private schools of basic education are in accordance with the best international practices, at least with regard to teacher training and teaching methodology adopted by them. Emphasizing what has already been mentioned in this section, it is necessary to make the teaching career in Brazil attractive, valuing teachers with more adequate training, so that the best minds in the country are attracted to teaching, avoiding losing these professionals to other market segments and/or other countries.

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